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HEREDITY AND SEX.*

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All higher organisms, whether plant or animal, have sexuality. It is only the very lowest that lack the sex potentiality and are truly nonsexual. The blue-green algæ, for example, appear to be such organisms. Apparently their protoplasm is not organized in such a way that sexual states can arise in it. But with an advance in cell organization, probably involving a more advanced and more complicated nucleus with definite chromosomes, the sex potentiality is introduced and the protoplast may then pass into any of the three conditions commonly manifested by sexual organisms, namely the female state, the male state, or the neutral state.

When sexuality first appeared it was manifested only as a physiological state. No dimorphism is in evidence. The sexualized cells simply take on a peculiar property, for the time being, by which they are attracted in pairs, come together, and fuse into one unitary protoplast. This is a most remarkable process. Although the chromatin from the two gametes is inclosed in the same nuclear membrane, it is not commingled but the individual chromosomes from each parent gamete retain their identity and hence a diploid condition is established in respect to the chromosomes. After the fusion, all evidence of a primary female state (p. +) or of a primary male state (p. —) disappears in a neutral condition of the cell. But when the zygote undergoes its first division after the fusion process, or at some subsequent division, a second primary sexual phase is inaugurated, but this time it does not involve the protoplast as a whole but only the individual chromosomes in the diploid nucleus. These bodies now show the same remarkable attractive

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property toward each other in specific pairs as the gametes did formerly, undergoing a primary plus (+) and minus (—) sexualization, and thus come together as fused but not commingled pairs and are then separated to the opposite poles by the division spindle. These two processes of primary sexualization—the conjugation of gametes resulting in a unitary protoplast with a diploid condition of the nucleus and the reduction division resulting in a specific synapsis of chromosome mates and their segregation—are present in all organisms with normal sex potentiality. The diploid chromosomes are sexually neutral in respect to each other, that is they do not have the primary sexual plus and minus states, except during the reduction division phase no difference whether the tissues in which they are situated are in the secondary female state, in the secondary male state, or in the neutral state. As the result of the evolution of the primary sex potentiality, the lowest sexual organisms, therefore, exist in one of the three conditions, primary female state, primary male state, and neutral vegetative state and the chromosomes as individuals may partake of these states along with the state of the cell as a whole or as individuals independently of other parts of the protoplast. The neutral state of the cell may occur both between fertilization and reduction and between reduction and fertilization. The neutral state may disappear in fertilization or it may continue for many vegetative divisions. Likewise reduction may be followed by an immediate primary sexualization of the entire protoplast, or there may be many vegetative divisions following with a completely neutral condition of the haploid cells. Thus the primary sex potentiality is a property of sexual organisms, manifesting itself in various peculiar states during the cell lineage cycle. The potentiality is not inherited as a male potentiality, a female potentiality, or a neutral potentiality since the same complement of chromosomes with the same heredity may exhibit all three states from time to time.

In the progressive evolution of plants and animals the time of sex determination is shifted backward from the mature condition of the gametes to the beginning of gamete development, and thus a dimorphism arises in an orthogenetic progression until the extreme is reached in the highly dimorphic egg and sperm. This dimorphism of egg and sperm as contrasted with the more primitive isogamous condition is characteristic of all higher plants and animals. The heredity

determining the gradients is never lost. The dimorphic character expression which appears in the sperm and egg may not be caused by the primary male and female states themselves, but perhaps by secondary states which may precede them. Since we have no means at the present time of determining the actual differences between primary and secondary states except through the activity of the cells sexualized and no means of ascertaining whether the primary states of the gametes are preceded by secondary states, it is of no special importance to distinguish between them at this point in the ontogeny.

In some, more advanced organisms partial primary sexual states may arise giving the cells the property of attraction but not of fusion, or of cytoplasmic fusion for the time being. At a later stage primary sexualization is completed and fusion of the nuclei then takes place promptly. The further progress in the evolution of sex is the appearance of secondary sexual states and secondary sexual dimorphisms. These potentialities are universally present in all the higher plants and animals. This evolutionary progress is brought about by the introduction into the hereditary mechanism of the protoplast of multicellular organisms of a potentiality, or set of potentialities, by which the sexual state is determined in the ontogeny before the time of gametogenesis has been attained. The cell lineage passes from a neutral vegetative state to a sexual vegetative state, either male or female, and in consequence of these states the hereditary expression of characters is modified, giving rise to secondary sexual dimorphisms, the so-called secondary male and female characters. Since a large part of the lower multicellular organisms, which have heterogany, are hermaphroditic and also the greater part of the heterosporous sporophytes bisporangiate individuals, it follows that in the greater number of plant species, as well as in hermaphroditic animals, there is really a trimorphism normally present, consisting of the neutral tissues and organs, tissues and organs with secondary female characters, and tissues and organs with secondary male characters. All these states are but phases in the development of the individual organism and are developed from protoplasts having a common heredity and with exactly the same complement of chromosomes. Neither the specific character of the heredity involved nor the shifting of chromosomes with the hereditary potentialities can have anything to do with the matter, for the simple reason that no shifting is taking place.

The secondary sexual states have been defined as having the property of influencing the functional activity of the cell in such a way that the hereditary expression is changed. The same hereditary complex gives a different character when the secondary male state is present than when the secondary female state is present and thus a sexual dimorphism results either through an influence on latency and activity of the various hereditary factors present or else by causing the factors to act in a different way under the two conditions. The phenomena of sexual expression are the same in diecious plants. In many genera containing both monecious and diecious species there is absolutely no apparent difference in the dimorphic characters except that in the first only a part of the system is involved in the one sex expression or the other while in the second the entire individual is involved.

The secondary sexual state, as manifested in the protoplast as a whole, always precedes the primary state and in the higher plants with an alternation of generations the sexual states are normally determined but once in the life cycle. When the secondary male state or the secondary female state is once established it remains underchanged, except in case of abnormal sex reversal, even through the reduction division, until the primary sexual state is attained in the gametes and neutralization is accomplished in fertilization. This is true for all heterosporous plants except the comparatively few diecious species and the statement is true for the diecious species also except that in this case fertilization may not end in neutralization. It must be emphasized that it is not proper to consider any cell of a sexual organism as having only male potentiality, neutral potentiality, or female potentiality. But the proper mode of thought, agreeing with the actual phenomena known and to be attained through experiment, is that any given cell has the sex potentiality which for the time being is in the male condition in respect to its functional activity and morphology, in the neutral condition, or in the female condition. Any of these states are potentially possible whether the given cell lineage is diploid or haploid and in any given sexual state for the time being. Such series can be observed or produced in any number of diecious, monecious and bisporangiate-flowered species as well as in haploid and diploid moss protonemas.

The whole modern development of the science of sex as postulated on Mendelian notions shows up in an absurd light

when one considers carefully the enumeration of facts given above and a multitude of others that might be adduced. How has it come that sex was considered Mendelian when we have known from the beginning that in the higher plants, for example, the sexual states and sexual dimorphisms are never changed, are never determined, and are never segregated at the time when the chromosomes with their hereditary potentialities are segregated? There is no real analogy between sex expression in the individual and the alternative inheritance of dominants and recessives in Mendelian heredity. Any race may contain only one of these Mendelian allelomorphs, for they are merely units of subordinate importance, but a race, whether with hermaphroditic or unisexual individuals, must have potentialities for both sexes if fertilization and reduction are to occur at all. Dominants and recessives are not phases of the same potentiality but are distinct, segregative potentialities whereas femaleness and maleness and neutrality are phases of a general sex potentiality in the same individual and only in advanced forms does a single condition usually appear in the individual and here the condition may also be reversed without change of the heredity present as has been repeatedly done in many species by direct experiment. Furthermore, the presence of a secondary male or female state in the protoplast does not interfere with the development of primary plus (+) and minus (—) reactions between the synaptic chromosome mates. When the sex of either a unisexual individual or a unisexual branch of a hermaphroditic individual is reversed, the entire complex of characters of the one sex or the other is normally expressed as a whole, because the given complement of sex characters is but the result of the peculiar bent given to the hereditary expression through the influence of the state present. The only exception to this arises when special heredities are present or lacking in the allosomes which would, of course, cause special expressions of the allosome-linked factors.

Any given hereditary constitution will give a special functional gradient, in the normal environment, which will determine the point in the ontogenetic cycle when the sexual state will be determined one way or the other. These different types of heredities form, like all fundamental evolutionary movements, a definite orthogenetic series. In every case the physiological state through which the sex is determined from the neutral condition to the plus (+) or minus (—) condition,

or is shifted from one sexual state to the other at a given point, is due to a hereditary constitution inherent in the cell. One or more potentialities in combination with the environment determine what the physiological state is at this point. Changing either the hereditary potentiality or the environment sufficiently to change the functional state will shift the point of determination at which the sex balance will be tipped one way or the other.

If we should attempt, at the present time, to extend the theory of Mendelian potentialities to the organism as a whole, to the property of protoplasm by which it is able to carry on respiration or assimilation, to the potentiality or property that determines whether the sex shall be determined in the gametophyte or in the sporophyte, to the properties that distinguish the great phyla, to the profound dimorphism exhibited between gametophyte and sporophyte in the life cycle, to the dimorphic expression of sterile and fertile shoots, to the dimorphism of foliage leaves and sporophylls on the same individual, to the dimorphism of root and shoot, the attempt could not but be regarded as fantastic. Yet the Mendelian conception of sexuality when considered from the standpoint of the actuality of sex phenomena is just as impossible. The notion that many have that an individual with sex potentiality cannot be wholly neutral but must be either male or female is equally fantastic. The sporophyte of a fern shows no maleness nor femaleness. The moss sporophyte shows no sexual dimorphism. Yet we know that the sex potentiality is there, and without changing the chromosome complement in the cells, without subtracting or adding a single gene, we can take this homosporous sporophyte and compel its sex potentiality to produce both normal secondary male and female characters and also primary male and female states. It is entirely wrong to say, like Goldschmidt and others, that sexuality is represented by M (male sex genes) and F. (Female sex genes). If we were rash enough to postulate genes for the various sex conditions we would certainly demand an N. (neutral genes) for fear that homosporous sporophytes would otherwise disappear from the earth. And while we were in the gene-making business we would want a gene for the primary female state which appears in the egg and another one for the primary male state which appears in the sperm. Goldschmidt and others of like mind are simply confused by the phenomenon of sex reversal which they are

not able to fathom, apparently because they hold to a static notion of the organism rather than conceiving of it in terms of growth gradients, even though they may profess to hold to the physiological conception of heredity. Every cell of a sexual organism has the potentiality of passing, in its lineage, into the male and female and neutral states and expressing structures corresponding to these three conditions as will be shown below.

Sexuality then is due to a potentiality of a general nature and when this potentiality is present a cell may pass into any of seven peculiar states and develop characteristic activities peculiar to each state. The seven general states are to be considered as a gradation system and each of the states can be present in different degrees of completeness and intensity. The seven states are: 1. Complete primary female state, 2. Incomplete primary female state, 3. Secondary female state, 4. Neutral state, 5. Secondary male state, 6. Incomplete primary male state, 7. Complete primary male state. The incomplete primary female and male states are in evidence only in certain thallophytes so need not be considered generally. But the five states are usually to be met within most of the sexual plants. The neutral state must not be confused with a vegetative state since there is neutral vegetative growth and activity, as in homosporous sporophytes, female vegetative growth and activity, as in female gametophytes and carpellate sporophytes, and male vegetative growth and activity, as in male gametophytes and staminate sporophytes. Now the time and mode of appearance of sexual states in the ontogenetic cycle is conditioned on a multitude of different hereditary constitutions. Each type is conditioned by a distinctive type of heredity controlling the functional gradient in relation with the environment in which the organism normally lives. A change of environment will, if extreme enough, change the normal mode of appearance and condition of the sexual states naturally developed, especially in the higher, more extreme forms as in monecious and diecious species and in the autoicous and unisexual gametophytes of homosporous Metathallophyta.

The following list gives the typical cases presented by the plant series.

1. The lowest organisms, which have a hereditary constitution without sex potentiality. Examples—*Merismopedia*, *Nostoc*.

2. Organisms which have a hereditary constitution which produces functional gradients that permit of primary sexual

states only and these arising only in the gametes after their complete development. The gametes are, therefore, completely isogamous and the other cells in the lineage are always completely neutral. Examples, *Diatoms*, *Desmids*, *Sphaerella*, *Ulothrix*.

3. Some lower organisms have a hereditary constitution that causes sexual states to arise in the gametes before comp'ete maturity. Thus the completion of the development is carried on under the influence of one or the other sexual states and a partial or moderate sexual dimorphism of the gametes is produced. Examples—*Pandorina*, *Bryopsis*, some species of *Spirogyra*.

4. Organisms that have a herditary potentiality which causes sex-determination to take place at the very beginning of gametogensis, and thus producing extremely dimorphic gametes, the usual condition of heterogamy. Examples—*Volvox*, *Sphaeroplea*.

5. The herdity of the organism is such that a functional gradient is developed which produces a condition that the sex-balance is tipped at the beginning of the development of the gametangia, resulting in decidedly dimorphic gametangia as well as decidedly dimorphic gametes. There is a secondary sexual state and a secondary sexual dimorphism established before the primary dimorphism appears in the gametes. Examples—*Monoblepharis*, *Vaucheria sessilis*, *Coleochaete*.

6. The herditary potentiality produces a gradient that develops the condition for sex determination in the vegetative phase sometime before the gametangia proper appear, giving rise to secondary sexual dimorphism in the vegetative parts of the gametangia and beyond, as wel as secondary dimorphisms in the gametangia and primary dimorphisms and primary sexual states in the gametes. Examples—*Chara*, *Fucus evanescens*, *Vaucheria synandra*, *Oedocladium protonema*.

7. Organisms, either haploid or diploid, in which the hereditary constitution is such that a physiological condition arises at the very beginning of the ontogeny, or in the spore from which the individual originates, which indues a sex determination and thus the entire individual is unisexual, either a male or a female. This is the normal unisexual condition present in some organisms with a simple haploid sexual cycle and in some with a simple diploid sexual cycle. Examples—*Rhizopus nigricans*, *Fucus vesiculosus*.

8. Organisms with a typical antithetic alternation of generations in which the hereditary potentialities are such that the gametophyte is sexually neutral up to the time when the gametangia develop and the ontogenetic gradient arrives at the point of sex determination just at the beginning of the formation of the gametangia. There is thus secondary sexual dimorphism of the gametangia and primary sexual dimorphism of the gametes but the sexual states being neutralized in the fertilization process, the sporophyte remains entirely neutral, its sex potentialities being completely latent under the functional gradients established. Thus there is a complete lack of sexual dimorphism and sexual states in the normal sporophyte and the same condition holds over in the vegetative phase of the gametophyte up to the time of the appearance of the incepts of the gametangia. The gametophyte is synoicous. Examples—*Fosombronia foveolata*, *Bryum arcticum*.

9. The organism is in general the same as in the 8th type but the hereditary constitution is such that the reproductive branch of the gametophyte passes first into the one sexual state, either male or female and after a time the gradient of the growing branch changes and a sex-reversal takes place, the later development of the growing bud giving rise to the opposite kind of gametangia from what were developed first. This is the paroicous condition. Examples—*Cephaloziella elegans*, *Catharinaea undulata*.

10. Organisms with an antithetic alternation of generations in which the heredity is such that incipient reproductive branches are determined in the secondary male and female states which remain without reversal in the given branch. The gradients which arise in the branches are so evenly balanced that part of them fall into the secondary male state and part into the secondary female state. The conditions of the ontogenetic gradients are, therefore, quite different from those in the 9th type but are similar to the balance produced in certain spores and zygotes in which the poise of physiological state is also so delicate that about half fall to the male condition and about half to the female. These are the organisms with autoicous gametophytes. Examples—*Cephaloziella hampeana*, *Hypnum riparium*.

11. Certain mosses with branched protonema whose hereditary potentialities are of such a nature that sex determination apparently takes place in the incipient gametophore buds,

each entire scaly gametophore arising from the protonema being either completely male or completely female. No cases definitely established. In some species the female plant apparently gives rise to secondary protonemata from which males develop. Example—*Camptothecium lutescens*.

12. Bryophytes and homosporous pteridophytes in which the sex is determined in the tetraspore. In a few species allosomes are present and are segregated in the reduction division. These allosomes appear to have a definite sex association and may have differential heredities which produce differential functional gradients so that under the usual conditions the sex balance always falls in a given direction in the given case. In the sporophyte these allosomes have no influence, the sporophyte being completely neutral. Regeneration in the sporophyte tissue would probably cause sexual states to appear as has been discovered for numerous mosses. In the vast majority of cases no allosomes have been discovered in plants of this type, as in many unisexual liverworts, mosses, and homosporous pteridophytes like *Pteretis nodulosa* and *Equisetum arvense*.

In the two last mentioned species, sex reversal in both directions is easily induced experimentally. Now these individuals are haploid and there is therefore no correspondence with the notion that their unisexuality is produced by the segregation of sex-determining chromosomes or factors. There is no more basis for such an assumption than for that which considered that gametophytic and sporophytic dimorphism was dependent on haploid and diploid conditions. The remarkable dimorphism exhibited between gametophyte and sporophyte can be produced in the diploid condition without any change of chromosomes or hereditary potentiality. This shows the superficiality of the view that to obtain unisexuality we must in some way be segregating male-producing or determining herdity from female, or male-producing chromosomes from female-producing chromosomes. It is remarkable that in spite of an endless array of experimental evidence, purely fantastic ideas still sway a considerable portion of biologists who cannot get beyond a crude biological confession of faith which was formulated not through a consideration of the actual phenomena of sexuality in relation to heredity and the life cycle but almost wholly through a blind belief in a series of false biological postulates. In changing from one sexual state to the other it

is often much easier to make the change in one sex than in the other. Thus in the ostrich fern it is much more difficult to change male to female than female to male, presumably not because of a lack of potentiality but because of the greater special differentiation of the male gametophyte in this case. Examples as indicated above—*Marchantia polymorpha*, *Sphaerocarpos* sp., *Mnium punctatum*, *Equisetum arvense*, *Pteretis nodulosa*.

The condition in some mosses of unisexual haploid gametophytes and completely neutral diploid sporophytes presents certain aspects fundamentally important to a correct understanding of sexual phenomena in general. The neutrality of the sporophyte is not produced by the balancing of chromosomes or genes of opposite potentialites but because of a condition and gradient established at the time of fertilization which begins a certain differentiation cycle from which the individual normally does not depart throughout its entire ontogeny, ending in determination and death. Now, as intimated above, we know from various experiments, made by various investigators on unisexual mosses, that a protonema can be sprouted from the neutral diploid sporophyte tissue and a new gradient established producing the marvelous result that the same complement of chromosomes with the same hereditary potentialities which produced a neutral or so-called "non-sexual" sporophyte now develops a sexual gametophyte, and furthermore, sometimes this gametophyte is hermaphroditic but occasionally it is again unisexual showing pure male or pure female expression.

One of the more recent investigations along this line was carried out by Schweizer on *Splachnum sphaericum*. The diploid protonema regenerated from the diploid tissue of the sporophyte, although it usually produced hermaphroditic gametophytes nevertheless also produced some pure male and some pure female gametophores, which is the normal condition of the haploid gametophyte. It is perfectly plain, therefore, that the sex-determination and sex-differentiation are dependent on functional states—differentiation states and constancy of differentiation after determination—and not at all on differential heredities, since, with the same heredity present, the functional gradients in the several cases nevertheless bring out pure female, pure male, and hermaphroditic gametophores.

After passing the twelve more striking types in which the sex is normally expressed in the gametophyte, we come to the heterosporous, higher plants where a remarkable shift takes place, an hereditary constitution now having evolved that sooner or later springs the sex balance in the sporophyte; in other words causes some cells to pass into the secondary male state, some into the secondary female state, and in the majority of cases some into the neutral state; whereas all the previous sporophytes with their diploid chromosome complements have normally always developed in a completely neutral condition. Furthermore, the evolutionary movement continues in exactly the same way as it did in the gametophyte. The first phase shows a sex-determination taking place only at the beginning of sporangium development and this is followed by evolutionary movements in a multitude of cases in which the final forms always have their sex determined at the very beginning of the sporophyte ontogeny.

13. The plant has a hereditary constitution which produces a functional gradient in the diploid sporophyte of such a nature that a neutral vegetative body is developed but when the point in the determinate process of the sporophyll is reached where sporangia are developed in the sorus, the incepts of the sporangia pass into the secondary sexual states, some to the secondary male state, and some to the secondary female state, thus giving rise to secondary sexual dimorphisms in the sporangia themselves and their stalks. This secondary sexual state also changes the activity of cell division greatly so that many divisions usually occur in the sporgenuous tissues of the microsporangium and comparatively few in the sporogenous tissue of the megasporangium.

The megasporocytes are also all destroyed in the megasporangium except one. These differences show the profound influence which the secondary sexual states may exert on the activities of the cell. Since sexuality has nothing to do directly with heredity, there is no influence on the sexual states during or after the reduction division. The microsporocytes which are in the secondary male state permit of the primary plus (+) and minus (—) sexualization of their diploid sets of chromosomes with consequent synapsis and segregation. All four cells remain in the secondary male state and produce a tetrad of microspores. Exactly the same process takes place in the megasporocyte which is in the secondary female state. All

four of the resulting cells remain in the secondary female state and develop as four megaspores. In many cases, however, only one of the four develops into a functional megaspore. Examples—*Marsilea*, *Pilularia*.

The secondary sexual dimorphism which distinguishes the megaspores and microspores is of the same general nature as the primary sexual dimorphism which distinguishes the gametes of all heterogamous organisms, but there is, of course, no primary attraction, and there are no swiming organs on the microspores. Since the spores have their sex determined they give rise to distinct unisexual gametophytes. And it is well to call attention again to the fact that the development of maleness and femaleness in the two gametophytes has absolutely nothing to do with any specific or differential heredity which they may possess.

14. Heterosporous pteridophytes with a hereditary constitution which produces a functional gradient that determines a secondary sexual state, either male or female, in the incept of the sorus. Otherwise these plants are essentially the same as type 13. Examples—*Azolla*, *Salvinia*.

15. Some heterosporous pteridophytes in which the sexual states are determined in the incepts of the sporophylls, some passing to the secondary female state and some to the secondary male state. Examples—some species of *Selaginella*.

16. Heterosporous plants which produce a determinate floral axis of the sporophyte of such a nature that the bud passes from the neutral condition first to the secondary male state with the production of stamens (microsporophylls), and then through a sex reversal to the secondary female state with the production of carpels (megasporophylls). This is the usual normal condition in some fossil gymnosperms and in the Anthophyta from Magnolia up to the dandelion. Examples—*Echinodorus*, *Ranunculus*, *Rosa*, *Lilium*, *Oenothera*, *Vernonia*, *Lactuca*.

17. Flowering plants which have a neutral condition of the sporophyte up to the formation of the flower buds. The functional states are so evenly balanced that some of the incepts of the flowers in the same inflorescence fall into the secondary female state and some into the secondary male state and remain in these conditions up to the time of determinate growth. Examples—*Cocos*, *Aesculus*.

18. Flowering plants with a hereditary nature that produces a gradient in the incept of the inflorescence bud of such a nature that a secondary female state is established with con-

sequent production of carpellate flowers for some time and then through a sex reversal ends with the production of staminate flowers. Examples—*Sagittaria latifolia, Tripsacum dactyloides.*

19. Flowering plants with the sex conditions just the reverse from that in type 18, the secondary male state developing first and the secondary female state later. Thus the staminate flowers are below and the carpellate flowers above in the inflorescence, coming in the same order as the sporophylls in the typical bisporangiate flower. Examples—*Zizania aquatica, Ricinus communis.*

20. Flowering plants and conifers with a hereditary nature that produces functional gradients that secondary sexual states arise long before determination sets in, giving rise to large vegetative branches showing a distinct secondary sexual dimorphism. Examples—*Zea, Taxodium, Carex lupulina.*

21. Flowering plants and gymnosperms which have a hereditary constitution of such a nature that a functional state arises in the egg, either before fertilization is completed or afterward, which causes one or the other secondary sexual states to be established, the balance falling either to the male condition or the female condition and in consequence the entire diploid sporophyte shows more or less secondary sexual dimorphism. This is the ordinary diecious condition which exists in many degrees of intensity and fixity in various species of the Cycadophyta, Strobilophyta, and Anthophyta. The sexual condition of the individual is often subject to easy sex reversal and re-reversal so that intergrading individuals are produced in special environments. In some species such sex reversal rarely takes place. Examples—*Acer, Thalictrum, Morus, Acnida, Cannabis, Arisaema triphyllum.*

22. Diecious plants with dimorphic chromosome sets (allosomes) probably always with some differential hereditary potentialities, which may influence the functional gradients on which sex determinations depend. Such plants are subject to sex reversal the same as plants without allosomes. These dimorphic allosome conditions presumably have been brought about by hybridization, as suggested by Miss Blackburn either through the crossing of related species (probably diecious species of type 21) or through a more direct mutation in the species involved which would thus establish a hybrid condition. Sexuality with its reciprocal interaction between male and female gametes made the allosome condition of the sporophyte possible

as a final step in the evolution of the numerous sexual conditions which actually exist at the present time. The allosome condition is the result of sexuality, and unisexuality of the individual is not primarily caused through allosomes, because as stated previously, unisexuality of the higher gametophytes has no correspondence with allosome distribution, and the diecious condition of the sporophyte commonly shows no allosome difference. Examples—*Humulus japonicus*, *Lychnis dioica*.

Anyone who knows anything at all about the evolution of organisms in general and of plants in particular knows that allosomes are not at the basis of sexuality nor of the sex conditions but are mere incidents in the evolutionary development of the various sex conditions. It is also evident that there can be no Mendelian factors for sexuality expressed either as maleness, femaleness or neutrality. When allosomes of a differential nature are once established there may be differential varieties of pollengrains or different varieties of sperms which might react in a distinctive manner to the eggs at the different levels of the gradient through which the egg passes. But in the angiosperms, since there is no free interaction between egg and sperm possible but the egg must unite with whatever type of sperm that the pollentube brings to it or remain unfertilized, it is reasonable to assume that the egg is as evenly balanced as it is in the diecious species without allosomes and which usually produce about an equal number of staminate and carpellate individuals. Then the slight differential condition between the two types of sperms containing the two types of allosomes would cause the functional gradient to go up or down as the case may be and thus put the zygote on the road toward maleness or femaleness. This is probably the correct view of the matter in harmony with the general phenomena of sexuality in both plants and animals. The allosomes are neither sex determiners nor sex producers, nor do they contain sex genes or potentialities but they may and probably do contain differential physiological factors which may be only of a very slight influence after all but are of sufficient force to change the gradient in the evenly balanced fertilizable egg. When the sexual states are once established, differentiation in the male condition or the female condition will amplify the given sexual state, and in some, depending on the general hereditary constitution, the established sexual state will become so extreme that it is practically impossible to throw the system over into the opposite condition,

while in others this is very easily done. Thus we see how the sex of a diecious plant with allosomes can be completely reversed, because the allosome although present in every cell is neither a sex determiner nor a sex producer. This result follows because, as stated above, the allosomes do not possess any factors which are Mendelian sex determiners.

There are, of course, many types of hereditary constitutions, besides the 22 outlined above, which give distinctive functional gradients and functional states with distinctive phenomena of sex determination and sex conditions but the 22 types given show all the phases that one usually has to deal with in a practical way. In all these cases it is, of course, understood that the herditary expression is taking place in a given normal environment. With a change of environment the same heredities may and often do produce quite different expressions.

CONSIDERATION OF SPECIAL CASES OF SEX DETERMINATION.

THE HEMP (*Cannabis sativa*) probably does not contain allosomes but it is a typical, dimorphic, diecious species. Sex reversal can be brought about in any degree up to complete reversal to the opposite condition. In reversal, this species shows a gradation of conditions from no reversal whatever to complete change to the opposite sex. This series gives absolutely no warrant for assuming a multiple factor series of any kind. The result is due to degrees of differentiation and inequality in detail of environmental conditions. That this is true can be demonstrated through rejuvenating the individuals and then causing reversal in the second differentiation cycle when there was none at the first. Hirata apparently found that selfed carpellate plants tended to repeat the carpellate condition while selfed staminate plants produced both sex conditions more readily. If such a condition really exists it indicates that the pollen and sperms produced on the carpellate plants, although they proceed far enough in catalase reaction and other peculiarities to develop the primary male state in the sperms are, nevertheless, not extreme enough to tip the balance in the egg toward maleness, although some individuals are apparently more strongly female than others. Since the selfed staminate plants tended to produce both carpellate and staminate individuals we can assume that while the sperms are all in the normal, extreme male state, the eggs from these reversed plants

to develop or function at all must manifestly tend slightly toward the female condition at the time of fertilization. Thus when fertilization takes place with self sperms the sex balance works in the normal way as when cross fertilization occurs between a carpellate and a staminate individual. However, it must be recognized that the performance of any individual in any given environment is not to be taken as evidence of its sex potentiality since we know that these selfed reversed plants necessarily had a potentiality to produce both sexes under the conditions in which they were growing. The given expression is then nothing but an indication of the ease or degree of sex reversal in the environment in which fertilization and development are taking place.

The fact of sex reversal and the zonal development of sexual states in monecious plants and the similarly induced zonal development of sexual states in diecious plants like the hemp have robbed the sex-gene hypothesis of any plausibility it might have when considered in ignorance of these primary phenomena. In hemp, the writer took a pure carpellate plant and by a process of rejuvenation caused a zone of pure male expression with the production of typical and normal staminate flowers. Later this same branch reversed again to the pure female expression. Such a procedure cannot only be produced experimentally but may be observed in various diecious species out in the field. Any notion that the changes are due to losses of chromosomes or genes must be characterized as absurd in the extreme. With the advancement of our knowledge of producing rejuvenations and repeated rejuvenations, accompanied by re-reversals of the sex condition, no one will probably have the simplicity to continue to believe that chromosomes play any such hide and seek game of "now you have it and now you haven't."

Humulus japonicus. This plant has the allosome formulæ, carpellate AA and staminate AB. The carpellate plants are easily reversed to the staminate condition, to a greater or less degree, in spite of the presence of the AA set of allosomes and the staminate plants are easily reversed to the carpellate condition in spite of the presence of the AB set of allosomes. It is evident that the allosomes are not sex-determiners and probably not even sex-producers.

Honey bee (*Aphis melifica*). The honey bee furnishes conclusive evidence that sexuality is primarily not at all dependent

on Mendelian heredity, although we know that if the chromosome hypothesis of Mendelian segregation is correct, then Mendelian heredity is but a result of sexuality. The facts worked out by entomologists on the honey bee are apparently as follows: The workers and queens are females with the diploid complement (2x) of chromosomes. The workers are neuter females, having been developed as partial neuters through the manipulation of their environment by their nurses themselves during the developmental period and because the egg was deposited in a certain type of cell. The drones or males are hapolid (x) individuals having been developed parthenogenetically. There is, therefore, no evidence that an allosome is present or ever was present in the race. It is impossible to obtain such evidence unless the female had an AB set of allosomes in which case the male might have an A or a B. But the only difference seems to be that the female has a double complement of chromosomes and the male a single complement. If a worker develops functional femaleness, as is sometimes the case, all of her eggs develop drones. If a queen bee runs out of sperms, she produces nothing but drones no difference where the eggs are laid. In this case the drones developed in worker cells are said to be somewhat smaller than the normal.

Now the queen is a normal female with the double complement of chromosomes. These chromosomes have a hereditary constitution of such a nature that the diploid condition always throws the functional gradient of the developing egg toward the female condition or rather keeps it from going to the male condition. The eggs are produced through a reduction division in the usual way, all having the same kind of haploid complement of chromosomes. All of these eggs come from cells in the secondary female state and pass on to the development of the primary female state with the plus (+) reaction toward the sperms which are in the primary minus (—) or male state. So the queen may lay large numbers of eggs all fertilized. When she lays an unfertilized egg into a drone cell, this egg was also in the primary female state but because it is not fertilized its gradient goes over through the neutral state and then is reversed to the secondary male state. Most haploid eggs of plants and animals have a hereditary constitution that ends in stagnation and death when they reach the neutral condition, unless a special stimulus is applied from the outside to induce artificial parthenogenesis. But as indicated, the heredity

of the honey bee is such that the passing of the functional gradient through the neutral point does not lead to inactivity but rather to continued activity over to parthenogenesis and the secondary male state. The egg being now in the secondary male state develops a male with the haploid complement of chromosomes in its cells. There is, therefore, no proper reduction division at the maturation of the spermatozoa but the cells pass on from the secondary male state to the primary male state in the mature spermatozoa with the minus (—) sex reaction toward the eggs. Now we see that the same hereditary constitution, the same complement of chromosomes, without any material change whatever has passed from the secondary female state of the incipient egg, which state was handed over directly from the secondary female state of the queen's body, to the primary female state, to the neutral state, to the secondary male state of the drone's body, to the complete primary male state of the spermatozon. Yet there are numerous text-books, in perfectly good repute today, which by the easy method of reasoning in a circle pretend to explain such a simple series of evident phenomena by an appeal to the sex chromosomes and Mendelian sex gene hypothesis!

APHIDIDÆ. The condition in various species of plant lice is equally clear in demonstrating that allosomes follow the sex rather than determine it. In the aphids the summer environment gives rise to parthenogenetic diploid females and these females reproduce themselves for some time by producing diploid parthenogenetic eggs. Later in the season, however, a change takes place and these females produce cells of two kinds, some in the secondary male state and some in the secondary female state. The oocytes in the female state divide as before and thus the resulting eggs are normally diploid again. But the oocytes which have passed over to the partial male state undergo a change. Under the partial male state a synapsis is accomplished between the two pairs of allosomes although the autosomes are not so affected. The allosomes are so held together that two are lost out in consequence, and the resulting egg, although it has the diploid complement of autosomes, has only two allosomes instead of four as are present in the egg developed under the female state. Since the male and female states are developing further during the division states and the completion of maturation, they become large and small eggs when compared with each other. There are therefore large and

small eggs just as there are megaspores and micropores in the heterosporous plants and for the same general reason. The small eggs, being in the secondary male state, develop into male aphids and the large eggs, being in the secondary female state, develop into female aphids, just as the microspores develop into male gametophytes and the megaspores develop into female gametophytes, no difference what their allosomes or special hereditary constitutions may be. The sexual state determines the disposition of the allosomes in these aphids rather than that the allosomes are determining the sexual state.

DOMESTIC CHICKEN. In the chicken, the diploid individual with the female state contains but one allosome while the individual in the male state contains two. The allosome formula is thus female Ao, and male AA. Now in this case there is no difference in the hereditary factor constitution of the two individuals. The only difference is that the male is diploid in respect to the allosome A and the female haploid. The difference of the single or double state of the allosome may again effect the functional state of the egg as explained previously and so during the fertilization process the sex balance falls in the direction as indicated by the normal allosome formula of the sexual individual. But that the allosomes are neither sex determiners nor sex producers *per se* is plainly shown in the fact that a hen may be transformed into a completely functional rooster in spite of the fact that every cell in her body has the haploid condition of allosome A. The rooster may also go a long way in the transformation to the female condition, in spite of the fact that the allosomes in all the cells of his body are diploid.

VALLISNERIA SPIRALIS. Although the matter seems not to be definitely cleared up, according to Winge, it appears as though in Vallisneria the staminate plant has one less chromosome in the diploid generation than the carpellate plant. The formulæ for the sporophytes would then be: Carpellate, AAxx; staminate, Aoxx. This would be just the opposite from the condition in the chicken. There would be no fundamental difference in herditary potentiality between the male and female conditions except that one has the allosome A diploid and the other haploid.

Now it should be possible to find related species which could hybridize with resulting offspring in which the factors for various physiological gradients and conditions would be so evenly balanced that during the ontogenetic development the

sex determination balance would swing several times in one direction or the other giving rise to sex mosaics. In disturbed *Arisaema triphyllum* inflorescences and in the Indian corn tassel as well as in the flowers of hemp and Japanese hop such sex mosiacs are often in evidence. In fact any sex intergrade, is properly considered a sex mosaic, produced by the play of changing physiological gradients. In cases where the sex is reversed after rejuvenation in a second differentiation cycle, the process is fundamentally the same as when the sex mosaic appears in the first or normal cycle.

The more recent attempts at finding out the conditions of sex determination from self-pollinated reversed plants are again subject to misinterpretation long before any complete data are at hand for making categorical statements. In hemp for example, Hirata speaks of "females" and "female intersexes," but these terms can mean nothing except that under the given conditions the sex expression of the individual happened to be of that nature. We know that the presumption is quite firmly established at the present time that any hemp plant has the potentiality to be either "pure" male of female or a male or female intersex by simply bringing it into the proper environment. Labels put on an individual because of a single chance performance can mean nothing from the standpoint of critical analysis. Not all hemps have the same heredity in respect to the gradients established under a given environment. Some varieties produce intermediate individuals in the normal summer environment and some do not. But in both of these two types nearly all the individuals change to the intermediate condition when grown in a proper short light environment. Other conditions being proper, the change in sex expression is proportional to the length of daily illumination. Therefore it means nothing to label an individual as a "female" or a "male" or an "intersex" unless the label refers merely to the temporary mode of expression and not the potentiality through which the expression is produced. The label cannot imply a difference in constitution. Therefore, the conclusions drawn from such genetic phenotypic phenomena are of no primary genetic significance. Now in my experiments on hemp there was always a small percentage of individuals that did not change under the treatment given. But some of these individuals did change with a second treatment. There is no question but that all will change with proper environmental control. Furthermore, the degree

of sex reversal in the hemp plants, if estimated by the percentage of staminate and carpellate flowers produced, will be practically different for every individual. The diecious hemp and the diecious allosome-containing Japanese hop show the same gradation series as is shown in the sex reversal of the tassel by both the ordinary heterozygous Indian corn varieties and by highly imbred Indian corn, which are normally monecious. These sex series are fluctuations and one could manipulate the expression in such a way that there would be a continuous gradation series from zero up to one or two hundred degrees. These fluctuations are the facts which need explanation, and not only the fluctuations among individuals but the fluctuations of the same individual under different, rejuvenated ontogenetic cycles, which, as the writer has shown, can be easily produced. One may ask the questions: Why does the percentage of individuals showing sex reversal correspond with the ecological series? What makes the individual flucutate in sex expression with the environment? Why are the reversal series of the same type in the monecious species as they are in the diecious? The real crux of the matter is that a variety that is expressed as an intersex or hermaphrodite will under another environment be of a single or pure sex expression, and one that is expressed as pure will under another environment be expressed as an intersex or hermaphrodite. The thing works both ways as is evident by comparing the experiments on Indian corn and hemp. Until it is shown that this cannot be done there is nothing to argue about.

As to the fact that plants coming from selfed, reversed carpellate plants tend to produce femaleness and rarely decided male conditions, this should be expected since under the ordinary conditions one would expect the male gametes produced on the carpellate plant to be not extreme enough to cause the zygote to change its determination from the femaleness already present to maleness. And in the same way the staminate plant might in many cases tend to perpetuate maleness. If it does not do so in a given variety, it simply means that the eggs which are produced on the reversed parts of the staminate plant, because of the high metabolic activity of the organism as a whole, are not viable or functional unless they are developed to the extreme female condition, in which case they would then follow the usual method of determination and part fall to the male condition, on being fertilized and part to the female.

We know from experiment that the process of differentiation is not to be counted upon to give the same degrees of conditions in various specific cases. The physiological nature of sex must present a diversity of results in different species and one can only find out what the usual reaction is for a given environment with a specific hereditary complex by actual experiment. The next case may react quite differently. The facts obtained through breeding and ecological experiments can be explained by the fundamental physiological theory. They cannot be explained on the assumption of Mendelian hereditary factors. The vast majority of the facts of sex in plants and animals give a flat contradiction to any Mendelian hypothesis of sex whatever. What is inherited is the potentiality of sexuality, but this cannot be shifted out of any sexual protoplast. The sexual states developed as maleness or femaleness are not inherited as Mendelizing units, but, as explained earlier in this and other papers, in the vast majority of organic sexual types the sex is not changed nor determined by the shifting of the Mendelian factors. The factors are shifted while the sex condition remains unchanged.

At present it is impossible to think of Mendelian heredity except in terms of chromosome-linked heredity. Ever since the writer first discovered the true nature of the reduction division, while studying the cytology of *Lilium philadelphicum* in 1896-7, it has been evident that all normal Mendelian hereditary phenomena correspond with the aggregations and segregations of chromosomes during fertilization and reduction. The reduction phenomena were confirmed by a series of further investigations, one on *Erythronium* before Mendelian heredity was made known, and one on *Lilium tigrinum* several years after the Mendelian view of heredity was established. These laborious investigations established a proper basis for the explanation of Mendelian heredity. They were not accepted at first until the shere weight of Mendelian phenomena compelled a proper consideration. In the mean time a fundamentally false explanation of "crossing-over" has been foisted on an unsuspecting scientific public, which is absolutely without any cytological basis. True crossing over is a primary sexual phenomenon and a reasonable hypothesis of its cause and action can be developed. Instead of this we have the spectacle of a most profound cytological vagary which never did and never

could take place according to all the cytological evidence we now have.

As stated above, my discovery of the qualitative reduction division laid a firm cytological basis for an explanation of Mendelian heredity. In the meantime no other phenomena have been found which can explain Mendelian ratios, and linkage phenomena. Thus, for the present at least, Mendelian heredity rests on a firm chromosome foundation. But on the other hand, the phenomena of sex determination and sexuality show no such general correspondence. In fact, as has been repeatedly emphasized, there are only a few types of organisms where sex phenomena and chromosome phenomena coincide, and the vast majority of the most evident phenomena of sex are flatly contradictory to any Mendelian explanation whatever. The most evident contradiction comes in the 150,000 heterosporous plants in which the segregation of Mendelian heredity with the chromosomes during reduction never results in a segregation of sex. One might as well attempt Mendelian explanations for the transmission of heredity in the nonsexual Protophyta as to attempt to associate the cause of sexual states with chromosome shiftings. Those who speak innocently of Mendelian sex phenomena in the higher plants either do not know the chromosome history of these plants or else do not comprehend the presence of the non-correspondence. Neither secondary sexual states nor the sexual dimorphism of the reduction spores, nor the gametophytes which come from them, nor the primary sexual states of the gametes produced by them is in any way affected or influenced by the segregation of the chromosomes with their possible hereditary potentialities. Organisms either inherit a sex potentiality and are therefore sexual organisms or they have no such potentiality and are then nonsexual organisms. The sexual states which arise in organisms with sexuality and expressed as male, female, or neuter are caused by the interaction of physiological and ecological conditions.

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NOTES ON THE CHARACTER AND OCCURRENCE OF THE OLENTANGY SHALE IN SOUTHERN OHIO.

RAYMOND E. LAMBORN.

INTRODUCTION.

The Devonian shale where well exposed in central Ohio consists of two formations: the upper one is a black, carbonaceous shale several hundred feet in thickness which from its wide-spread distribution in this state is know as the Ohio shale, while the lower formation, about thirty feet in thickness, consists of soft blue clay shale interstratified with both limestone and black shale layers, and was named the Olentangy shale for exposures along the Olentangy River near Delaware, Delaware County, Ohio.[1] The character and thickness of the Devonian shale in central Ohio is well discussed by C. R. Stauffer in Bulletin 10 of the Geological Survey of Ohio where an occurrence of the Olentangy shale is described as far south as Bainbridge, Ross County, Ohio.[2] Blue shale at the base of the Devonian shale series is also reported by Foerste and Morse in northern Kentucky near Fox Springs, Fleming County, and near Olympia Springs, Bath County.[3] There is an area, therefore, extending along the belt of Devonian shale outcrops from Bainbridge, Ross County, Ohio, south to the Ohio River where the horizon of the blue shale beds at the base of the Ohio shale outcrops but concerning which very little published data is available. While engaged in field work for the Geological Survey of Ohio, the writer crossed this belt of outcrops at many places from southern Pickaway County to the Ohio River and made a study of the character and Stratigrapic relations of the blue shale at the base of the Devonian system. In a recent article entitled the Olentangy Shale in Southern Ohio[4] the writer has described in a very general way the outcrops of the blue shale in this area and has also discussed the

[1]Winchell, N. H., Geol. Survey Ohio, Vol. II (1874), p. 284.

[2]Stauffer, C. R., Geol. Survey Ohio, Fourth Series, Bull. 10 (1909), p. 38.

[3]Foerste, A. F., and Morse, W. C., Kentucky Geol. Survey, Bull. 16 (1912), pp. 27, 37.

[4]Lamborn, R. E., Jour. Geol., Vol. 35 (1927), pp. 708–722.

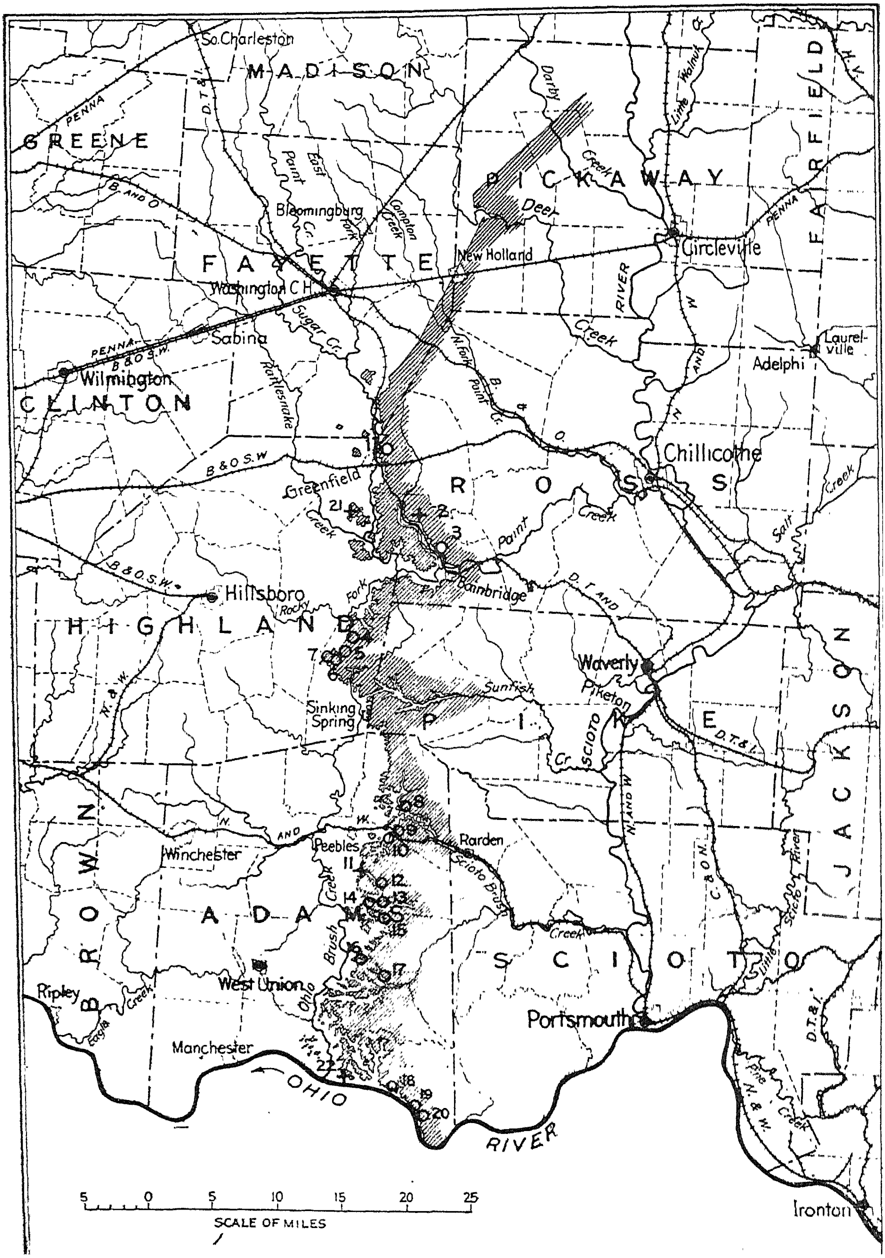

Fig. 1. Map of southern Ohio showing location of outcrops of the Olentangy shale. O, localities where the Olentangy shale is present; +, localities where the Olentangy shale is wanting.

stratigraphic relations and probable correlations of these beds but has omitted much of the detailed field data which is desired by some geologists. It is for the purpose of recording this data that the present paper is prepared.

In the area under discussion the Devonian rocks consist entirely of shale the base of which rests disconformably on the Silurian limestones and dolomites. The lower part of these shale beds was studied at twenty-two exposures, the locations of which are shown on the accompanying map. At eighteen of these localities the blue Olentangy shale is found in contact with the Silurian limestone and forms the basal phase of the Devonian system, while at four localities the blue shale is wanting and the black Ohio shale rests directly on the Silurian. The following notes and measured sections describe in detail the character, thickness, and stratigraphic relations of the blue shale at these localities.

Greenfield and Vicinity.

Greenfield is located in Paint Creek Valley in the northeastern corner of Highland County. With the exception of a few small outliers, the base of the Devonian shale outcrops along the eastern slope of the valley from Good Hope south to the mouth of Rattlesnake Creek. Two exposures were observed in this area as described below.

About one and a quarter miles northeast of Greenfield, the Good Hope-Clifton road is joined by a diagonal road from the northeast. A quarter of a mile above the junction of these roads and on the south side of the diagonal road, a few inches of the soft blue clay shale of the Olentangy formation is exposed above the Silurian dolomite, (Locality 1). South of Greenfield an outlier of Ohio shale caps the divide between Paint Creek and Rattlesnake Creek. Three-eighths of a mile west of Elliott School, along the diagonal road which crosses Rattlesnake Creek near the mouth of Cedar Run, the Monroe dolomite appears in the gutter with the black Ohio shale immediately above it, (Locality 21).

Bainbridge and Vicinity.

Bainbridge is located in the valley of Paint Creek in the southwestern part of Ross County. Two and a half miles northwest of this town, on the Cary Free farm, the Olentangy

shale is exposed in the bed of Rattlesnake Creek as shown in the following section, (Locality 3):

	Feet	Inches
Ohio Shale.		
7. Black, carbonaceous shale	3	0
Olentangy Shale.		
6. Soft, blue shale, weathering easily to a blue mud	6	2
5. Irregular layer of blue limestone	0	4
4. Light blue, clay shale	2	2
3. Dark blue, clay shale	2	0
2. Covered interval	21	0
Monroe Dolomite.		
1. Compact dolomite outcropping in the stream bed a few feet above the bridge	5	0

Three miles northwest of its mouth a small tributary enters Buckskin Creek from the north. Just north of the road and a little below the level of Sunnyside School, the base of the Ohio shale appears in the stream bed in close contact with the Monroe dolomite, (Locality 2). No evidence of the Olentangy shale is present at this locality.

Carmel to Slate Hill School.

To the west and southwest of Bainbridge the horizon of the Olentangy shale is generally covered with drift or talus deposits. However, a few poor exposures were found along the roads leading southwest from Carmel in the northwestern part of Brush Creek Township, Highland County, to Slate Hill School. The following section appears along the road one mile southwest of Carmel and five-eighths of a mile due north of Brown Hill, (Locality 4):

	Feet	Inches
Ohio Shale.		
6. Black, carbonaceous shale	6	2
Olentangy Shale.		
5. Bluish-gray, clay shale	0	6
4. Black, carbonaceous shale	0	1
3. Blue, clay shale	2	4
2. Black, carbonaceous shale	0	1
1. Soft, blue, clay shale	5	1
Covered to the base of the hill		

About a quarter of a mile West of Brown Hill, at the junction of the two roads, the following section was recorded, (Locality 5):

		Feet	Inches
9.	Black, carbonaceous shale	5	0
8.	Bluish-gray, fissile shale	5	1
7.	Covered interval	3	4
6.	Black, fissile shale	7	0
5.	Blue, clay shale	3	10
4.	Black, carbonaceous shale	0	11
3.	Blue, clay shale	1	0
2.	Black, carbonaceous shale	0	11
1.	Blue, clay shale	1	4
	Covered to the base of the slope		

A striking feature of the beds at this exposure is the alternating zones of black and blue shale. Of the twenty-four feet exposed in this section, fifty-five per cent is black shale and forty-five per cent is composed of blue shale.

About seven-eighths of a mile northwest of Slate Hill a north-south road crosses Franklin Branch of Rocky Fork. A few yards south of the bridge over this stream the Niagara dolomite and basal Devonian shale are exposed in the gutter as shown in the following section, (Locality 7):

		Feet	Inches
Ohio Shale.			
6.	Black, fissile, carbonaceous shale	30	0
Olentangy Shale.			
5.	Bluish-gray, clay shale, weathering to a red clay	5	0
4.	Covered interval	13	0
3.	Blue, clay shale	10	0
2.	Covered interval	6	2
Niagara Dolomite.			
1.	Dolomite	5	0

South of Carmel the limestone-shale contact follows a very irregular line passing through Brush Creek Township, Highland County; Mifflin Township, Pike County; and Franklin, Meigs, and Jefferson township, Adams County. At a number of places in this area blue shale is found as the lowest unit of the Devonian system.

Black Hollow School.

Black Hollow School is located in the south-central part of Franklin Township, Adams County, four and a quarter miles northeast of Peebles. The following section records the char-

acter of the rock outcrops along the road by the school house,[5] (Locality 8):

	Feet	Inches
Ohio Shale.		
11. Black, fissile, carbonaceous shale	10	0
Olentangy Shale.		
10. Bluish-gray, clay shale	6	2
9. Black, carbonaceous shale	0	6
8. Blue, clay shale	1	4
7. Black, carbonaceous shale	2	0
6. Soft, blue shale	33	10
5. Black shale, weathering to a chocolate brown color	5	2
4. Blue clay shale, with an occasional layer of black shale	7	6
3. Soft, bluish-gray, clay shale	3	0
2. Nodular iron ore	0	2
Monroe Dolomite.		
1. Dolomite	2	0

Beaver Pond.

Two and a half miles south of the last exposure is Beaver Pond Station on the Norfolk and Western Railroad. About a half of a mile west of the station a road crosses Cedar Fork of Scioto Brush Creek. A few rods east of this stream and opposite an old deserted house, the shale is well exposed along the road as recorded in the following section, (Locality 10):

	Feet	Inches
17. Black, fissile, carbonaceous shale	10	0
16. Blue, clay shale	1	6
15. Black, carbonaceous shale	0	10
14. Bluish-gray, arenaceous shale	0	8
13. Black, carbonaceous shale	6	0
12. Blue, clay shale	5	2
11. Black, carbonaceous shale	0	3
10. Blue, clay shale	4	2
9. Black, carbonaceous shale	0	1
8. Blue, clay shale	4	2
7. Black, carbonaceous shale	0	2
6. Blue, clay shale	0	6
5. Covered interval	5	7
4. Soft, blue, clay shale	5	10
3. Black, carbonaceous shale	1	3
2. Covered interval	3	0
1. Monroe dolomite	3	0

[5]Lamborn, R. E., Jour. Geol., Vol. XXXV (1927), p. 714.

The frequent recurrence of the interstratified black and blue shale is well shown in this section. Numbers one to nine record six periods of black shale deposition with beds ranging in thickness from one inch to six feet. The combined thickness of these black shale layers is about four-tenths the thickness of the blue shale.

About three-eighths of a mile northwest of Beaver Pond Station and along the road east of the railroad track, one foot of blue shale is exposed above the Monroe dolomite, (Locality 9). Three-eighths of a mile farther to the north, at the sharp bend in the road, ten feet of black, carbonaceous shale overlies the dolomite with no evidence of the Olentangy shale intervening.

Turkey Creek.

The next exposures to the south were observed along the valley of Turkey Creek, a tributary to the South Fork of Scioto Brush Creek. Here as farther north, the blue shale above the Silurian dolomite is not continuous. Two and a quarter miles southeast of Steam Furnace School the Monroe dolomite outcrops in the road at an elevation of 865 feet with a few feet of black, carbonaceous shale exposed above it, (Locality 11). The Olentangy shale is therefore wanting at this locality. One and a quarter miles farther southeast the pike is joined by a road leading from Peach Mountain. A few rods northeast of the junction of these roads the Monroe dolomite outcrops at an elevation of 800 feet. Several feet of blue shale are exposed in the gutter resting directly on the dolomite. The section follows, (Locality 12):

	Feet	Inches
Ohio Shale.		
8. Black, carbonaceous shale	15	0
Olentangy Shale.		
7. Covered interval	6	0
6. Bluish-gray, clay shale, exposed intermittently along the gutter	10	0
5. Blue, pyritiferous shale, with a few thin layers of black shale	10	4
4. Black, carbonaceous shale, weathering to a chocolate brown color	5	0
3. Blue, clay shale	5	0
2. Covered interval	2	0
Monroe Dolomite.		
1. Dolomite	2	0

One and three-eighths miles southeast of the last exposure the pike is joined by a road from the west. A half of a mile

west of the junction, near the home of Emile MacFarlane, the dolomite and overlying shale appear in the road yielding the following section, (Locality 13):

		Feet	Inches
10.	Black, carbonaceous shale	6	0
9.	Blue, clay shale	1	0
8.	Black, carbonaceous shale	0	6
7.	Blue, clay shale	0	6
6.	Black, carbonaceous shale	4	8
5.	Blue, clay shale	6	0
4.	Black, carbonaceous shale	0	6
3.	Blue, clay shale, with an occasional thin layer of black shale	6	4
2.	Covered interval	4	0
1.	Monroe dolomite	6	0

In numbers one to nine of this section three layers of interstratified black shale are shown ranging from six inches to four feet eight inches in thickness. These black shale layers constitute about thirty per cent of the total thickness of thirty-three feet six inches of the interstratified blue and black shale. In exposures of this type it is impossible to draw a line of separation between the two formations on lithological grounds.

Coleman Ridge.

Near the west end of Coleman Ridge in the northern part of Jefferson Township, Adams County, a road leading to the southwest in the direction of Cedar School intersects the Scrub Ridge road two miles southeast of the village of Scrub Ridge. A few rods northwest of the cross roads the following section was obtained, (Locality 14):

		Feet	Inches
Ohio Shale.			
12.	Black, carbonaceous shale	7	0
Olentangy Shale.			
11.	Blue, clay shale	2	6
10.	Black, carbonaceous shale	1	0
9.	Blue, clay shale	2	0
8.	Black, carbonaceous shale	0	8
7.	Black, carbonaceous shale	1	6
6.	Bluish-gray, clay shale	10	2
5.	Black, carbonaceous shale	0	6
4.	Clay shale	1	4
3.	Black, carbonaceous shale	0	8
2.	Covered interval	4	2
Niagara Dolomite.			
1.	Dolomite	1	0

Cedar Mills to Mill Creek.

Cedar Mills is located on Cedar Run two miles above its junction with Ohio Brush Creek. A half of a mile below the village, the valley road is joined by a road from the south which in turn forks a quarter of a mile below their junction. The west fork crosses the divide separating the drainage basins of Ohio Brush Creek and Scioto Brush Creek and intersects the West Union road near the junction of Bailey Run and Burr Run. The east fork crosses the divide near the Mount Zion School and follows the valley of Randall Run, a northern tributary of Mill Creek. Along the western fork of the roads, three quarters of a mile south of their junction, near a private road which enters from the east, an excellent exposure of the basal unit of the Devonian shales is found. A section of the outcrops is as follows[6], (Locality 16):

		Feet	Inches
23.	Black, carbonaceous shale	6	0
22.	Gray, clay shale	0	5
21.	Black, carbonaceous shale	1	1
20.	Bluish-gray, clay shale	0	6
19.	Black, carbonaceous shale	0	5
18.	Bluish-gray, arenaceous shale	0	10
17.	Black, carbonaceous shale	0	2
16.	Bluish shale	0	4
15.	Black, carbonaceous shale	2	0
14.	Blue, clay shale	0	8
13.	Black, carbonaceous shale	1	4
12.	Bluish-green, clay shale	0	10
11.	Black, pyritiferous shale	0	1
10.	Bluish-green, clay shale	1	0
9.	Black shale, weathering to a chocolate color	1	2
8.	Blue, clay shale	1	6
7.	Black, ferruginous shale	0	1
6.	Blue, clay shale	1	1
5.	Black, ferruginous shale	0	1
4.	Bluish-gray, clay shale	2	4
3.	Blue, pyritiferous shale	2	9
2.	Bluish-green, clay shale, weathering to a red clay	9	5
1.	Niagara dolomite, badly weathered	3	0

The alternation of the black and blue shale so characteristic of the basal unit of the Devonian shale of southern Ohio, is well illustrated in the preceding section. In some localities the beds

[6]Lamborn, R. E., Jour. Geol., Vol. XXXV (1927), p. 714.

of black shale are thin and their aggregate thickness is only a small fraction of the total thickness of the interstratified blue and black shale. At such places the contact between the Olentangy shale and Ohio shale formation is drawn at the top of the highest blue shale bed. Elsewhere as in the sections near Brown Hill, near Beaver Pond Station, and along Turkey Creek, these black shale beds become much more prominent and may equal or exceed the interstratified blue shale in thickness. In such cases no arbitrary line is drawn between these two formations.

The Olentangy shale is exposed at a number of places along the road in the valley of Randall Run. The full thickness of this blue shale occurs about seven-eighths of a mile northwest of the bridge across Mill Creek where the following section was secured, (Locality 17):

	Feet	Inches
Ohio Shale.		
7. Black, carbonaceous shale	6	0
Olentangy Shale.		
6. Blue, clay shale	0	10
5. Black, carbonaceous shale	1	2
4. Blue, clay shale, with an occasional thin layer of black shale	10	6
3. Black, carbonaceous shale	1	11
2. Blue, clay shale	1	9
Niagara Dolomite.		
1. Dolomite	2	0

Ohio River Valley.

The Silurian-Devonian contact in the Ohio River Valley follows a very irregular line from Ohio Brush Creek east to a point one mile southwest of Sandy Springs. Along the streams tributary to the Ohio River good exposures of the basal shales of the Deveonian may be seen.

Little Sulphur Creek.

Two miles northwest of Sandy Springs the river road crosses Little Sulphur Creek about three-eighths of a mile from its mouth. The base of the Ohio shale appears at water level beneath the bridge, while a few rods down stream blue clay shale outcrops along the bank. The character and thickness of these exposures appear in the following section, (Locality 20):

	Feet	Inches
Ohio Shale.		
10. Black, carbonaceous shale	6	0
Olentangy Shale.		
9. Bluish-green, clay shale	1	0
8. Black, carbonaceous shale	0	2
7. Bluish-green, clay shale	1	0
6. Black, carbonaceous shale	0	3
5. Blue, clay shale	1	4
4. Black, carbonaceous shale	0	3
3. Blue, clay shale	2	4
2. Black, carbonaceous shale	0	2
1. Bluish-green, clay shale	2	4

SULPHUR CREEK.

Outcrops of a similar nature are present along Sulphur Creek, a half of a mile farther to the west. A few rods below Sulphur Lick School the west bank of Sulphur Creek rises as a steep cliff exposing both the Ohio and Olentangy shales. A measurement of the beds exposed at this locality is given below, (Locality 19):

	Feet	Inches
Ohio Shale.		
12. Black, carbonaceous shale with a few large spherical concretions	52	0
Olentangy Shale.		
11. Blue, clay shale with a few thin layers of black shale	10	6
10. Black, carbonaceous shale	0	5
9. Bluish-gray, clay shale	0	9
8. Black, carbonaceous shale	2	6
7. Blue, clay shale	0	6
6. Black, carbonaceous and arenaceous shale	0	9
5. Blue, clay shale	1	0
4. Brown shale	0	3
3. Blue, clay shale	2	6
2. Covered interval	18	0
Monroe Dolmite.		
1. Hard, blue dolomite	4	0

From Sulphur Creek to Rome the dolomite rises rapidly and forms steep cliffs which border the river road on the north. About five-eighths of a mile northwest of Long Lick Run a deep ravine has been cut into the dolomite, and near its head the basal shale of the Devonian is well exposed. A measurement of the shale follows, (Locality 18):

	Feet	Inches
Ohio Shale.		
15. Black, carbonaceous shale	10	0
Olentangy Shale.		
14. Bluish-gray, clay shale	1	6
13. Black, carbonaceous shale	0	11
12. Blue, clay shale	0	10
11. Black, carbonaceous shale	1	2
10. Bluish-gray, clay shale	2	3
9. Black, carbonaceous shale	0	2
8. Blue, clay shale	1	1
7. Black, carbonaceous shale	0	2
6. Blue, clay shale	0	10
5. Black, arenaceous, ferruginous shale	1	0
4. Bluish-gray, clay shale	3	0
3. Black, carbonaceous shale	0	3
2. Bluish-gray, clay shale with many nodules of iron pyrite	8	10
Monroe Dolomite.		
1. Dolomite, badly weathered	5	0

About one and three-eighths miles east of the mouth of Ohio Brush Creek and an eighth of a mile north of Lockhart School, the top of the Monroe outcrops at an elevation of 850 feet. The Ohio shale lies immediately above the dolomite with no evidence of the intervening Olentangy shale, (Locality 22).

Conclusions.

The foregoing notes and sections of exposures of the basal Devonian rocks from Greenfield, Ohio, south to the Ohio River show the presence of a zone of blue clay shale at the base of the series which is quite variable in thickness and which is entirely wanting in some localities. The lithological characteristics and the general stratigraphic relation of this blue shale to the overlying black Ohio shale are similar to those of the Olentangy shale of central Ohio, although the zones of black shale interstratified with the blue shale become more numerous and thicker in southern Ohio, so that in some localities it is impossible to draw a sharp line of separation on lithological grounds. It is the writer's belief that the blue shale at the base of the Devonian shale series in southern Ohio represents a southward continuation of the Olentangy shale of central Ohio and that it is basal phase of the Ohio shale and therefore of the same age.

IODINE VALUE OF FATTY ACIDS FROM PLANT PHOSPHATIDES.*

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While much work has been done on animal lecithins and phosphatides, we find that, as yet, vegetable phosphatides have been very little investigated. Especially is this true of the fatty acids which may be secured by the hydrolysis of plant phosphatides.

Palmitic, stearic, and an unsaturated acid were found in various phosphatide preparations secured from seeds of Lupinus Albus by Njegovan (6). The iodine-value of the fatty acids from the various preparations varied greatly. Grafe and Magistris (3) using a preparation secured from Pisum arvense unicolor, secured flakes of a fatty acid which corresponded to palmitic acid. The most recent work along this line is that of Levene and Rolf (4) (5), who worked with phosphatide preparations secured from soy beans and identified stearic, palmitic, linolenic, linolic, and aleic acids.

It was felt desirable to determine whether or not the fatty acids secured from the phosphatides of various seeds are the same.

As there are a considerable number of methods of hydrolysis (2), (3), (7) it was deemed desirable to try out several of them on a sample of commercial lecithin and select the most satisfactory one for this problem. The methods and the iodine value of the resulting fatty acids are shown in Table I.

The samples were all refluxed over a flame, using 200 cc. of sulfuric or hydrochloric acid, and the heating was continued until the fatty acids separated and formed a clear layer on top. The sulfur dioxide gas was bought in cylinders and the carbon dioxide was generated from marble, using C. P. hydrochloric acid.

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TABLE I.

EFFECT OF VARIOUS METHODS OF HYDROLYSIS ON THE IODINE VALUE OF A LECITHIN SAMPLE.

TYPE OF HYDROLYSIS	IODINE VALUE	REMARKS
6% H_2SO_4	50.13	Fatty acid layer quite black.
6% H_2SO_4 + mossy tin	49.43	Fatty acids a light cream color.
6% H_2SO_4 + SO_2 gas	50.89	Fatty acids brown.
6% H_2SO_4 + CO_2 gas	49.86	Fatty acids brown to black.
10% HCl	51.24	Fatty acids dark.
10% HCl + mossy tin	52.54	Fatty acids light brown.
10% HCl + CO_2 gas	52.50	Fatty acids brown to black.
10% HCl + SO_2 gas	55.41	Fatty acids dark.
10% HCl + SO_2 gas	56.40	Fatty acids dark.

It is at once apparent that the use of sulfuric acid as a hydrolysing agent considerably lowers the iodine value, presumably either by oxidation or addition reactions at the double bonds; conversely hydrochloric acid in the presence of a strong reducing agent as sulfur dioxide seems to give considerably higher values and it was accordingly selected as the method to be used in the following work.

PREPARATION OF PHOSPHATIDE SAMPLES.

Since this is a preliminary study, no attempt was made to fractionate the phosphatides and the samples studied are the acetone insoluble fractions from the various seeds.

The seeds were ground thoroughly, then dried over night on a steam plate at about 95°C. They were then placed in an enclosed continuous extractor and extracted first with 95 per cent alcohol, then with ether, and finally again with alcohol. The alcohol and ether were then evaporated at a low temperature and the residue extracted with ether. The ether was then concentrated and acetone added in excess. The precipitate was then separated and twice more stirred up with ether and precipitated by the addition of acetone. Finally the precipitate was washed three or more times with acetone to insure complete removal of fats and the last traces of solvents allowed to evaporate, after which samples for phosphorus, nitrogen and hydrolysis were immediately weighed out so as to prevent any long contact with the air.

Methods of Analysis.

Total phosphorus determinations were made by digesting the samples with HNO_3 and H_2SO_4 and the phosphorus determined according to the method of the Association of Official Agricultural Chemists (1).

Total nitrogen was determined in the usual manner as described under Kjeldahl method, official, in the methods of the Association of Official Agricultural Chemists (1).

Hydrolysis was effected by heating the samples with 200 cc of 10 per cent HCl and bubbling in SO_2 gas until the fatty acids formed a clear layer on top. The samples were then cooled and the liquid siphoned off from the solidified fatty acids. These were then washed several times with boiling water and finally dissolved in ether and filtered. Aliquots were then removed from the ether extract (kept at 20°C.) to be used for iodine determinations and to determine the amount of fatty acids in solution. The latter were determined by evaporation of the ether.

Iodine number. The Hanus method, according to the Association of Official Agricultural Chemists (1) was used.

ANALYTICAL RESULTS.

Phosphatide Samples (Acetone Insoluble).

Source	Percent Nitrogen	Percent Phosphorus	Iodine Number of the Fatty Acids
Wheat (Poole)	0.99	1.26	81.49
Corn (Leaming)	1.14	1.65	65.30
Soybeans (Manchu)	0.70	0.495	92.48
Oats (Fulghum)	1.61	0.535	88.80

Summary and Conclusion.

1. Phosphatide material prepared in the same manner from different seeds varies widely in its nitrogen and phosphorus content, which fact indicates the desirability of fractionating the material for further study.

2. There is considerable range in the iodine values showing that there are either varying amounts of unsaturated fatty acids in the seeds, or that different ones are present.

The author wishes to express his thanks to the various members of the Department of Agricultural Chemistry of Ohio State University for their suggestions and cooperation in furnishing the material for the analytical part of this work.

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ORTHOGENETIC SERIES INVOLVING A DIVERSITY OF MORPHOLOGICAL SYSTEMS.*

STUDIES IN DETERMINATE EVOLUTION. II.

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In the first paper† of the present series dealing with the evolution of plants, a general survey was given of the fundamental, progressive movements which have taken place in the entire kingdom. The present study deals with several examples of morphological structures which require the evolution of a complex reaction system to bring about the harmonious development of all the parts. These special cases have been selected not because they are exceptional but because they represent rather bizarre examples, illustrating a condition which confronts us on every side—a progressive movement resulting in the development of a more and more perfect system until the ultimate limit is attained, which in some cases gives a condition of over-adaptation, in others a structure very useful, apparently, to the individual, in others a very "useful device" which is however of no utility whatever to the individual in the matter of survival, and in still others a structure which has no special use at all. Each of the three examples given begins in a very slight movement and ends in a remarkedly perfected consummation, which was of no importance in the first place and which could give no hint as to the remarkable end to which future steps would lead. As stated, such cases are present in great abundance all through the plant kingdom.

*Papers from the Department of Botany, the Ohio State University. No. 231.

†Schaffner, John H. The General Course of Evolution in the Plant Kingdom.

THE EVOLUTION OF A HIGHLY DEVELOPED BUR IN THE PANIC-GRASS TRIBE.

(See Plate I.).

Grasses in general do not have any special bristles developed at the base of the spikelet. The structures are usually naked or merely pubescent with epidermal hairs. In the genus Chaetochloa and related groups a new structure appears which in its simplest expression is represented by the presence of one or two stiff cortical outgrowths or bristles at the base of the pair of spikelets. *Chaetochloa verticillata* (L.) Scribn. is a typical example (Fig. 1). In this species the bristles are retrorsely barbed, as frequently occurs in structures of this type whether they represent modified spines, prickles, sepals, petals, or other organs. Formerly the possession of such a peculiar structure, especially if some apparent use could be found for it, was a plain case of use or disuse or natural selection. In the case in hand, however, the grains enclosed in the flowering glumes fall away when ripe and the bristles with their retrorse hooks remain behind on the dying plant. Had the bristles been attached to the abscissed fruit, it would have been a plain case of utililarian teleology to the credulous scientists of a generation ago. The important addition to the hereditary potentialities is something that is influencing the cortex to develop outgrowths when the ontogenetic gradient has reached the base of the pair of spikelets. The subsequent examples in this series will show how this peculiar character is increased step by step through a number of genera and many species.

Figure 2 represents *Chaetochloa imberbis* (Poir.) Scribn. which has 10 bristles at the base of the spikelets. These bristles are upwardly barbed, just the opposite from those of *C. verticillata*, and also remain behind on the old dead inflorescence when the spikelets are shed. If they were persistent on the abscissed spikelets, probably some one, still deluded by Lamarckian or Darwinian teleology, would claim that they were turned thus in order to prevent the bristles from clinging to passing beasts and men because they might thus be carried away too far and perhaps to an unfavorable habitat; since it is plain that they are in a favorable habitat already, otherwise the parent plant would not have survived to produce a crop of seed. Other species have bristles ranging between 2 and 10 and some have more.

In *Pennisetum glaucum* R. Br. there is not only an involucre of numerous stiff bristles and hairs around the base of the pair of spikelets (Fig. 3) but the cortical part of the stem bearing them is somewhat expanded. This represents a decided step in advance over the condition represented by *Chaetochloa imberbis*.

Figure 4 represents a low type of sandbur-grass, *Cenchrus myosuroides* H. B. K., which has a moderate development of prickles and a much more prominent cortical expansion round the spikelets. In figure 5, which represents the bur of our common sandbur-grass, *Cenchrus pauciflorus* Benth., the development of the basal cortical expansion is shown to have advanced decidedly and the prickles have become strong and rigid. The spines are retrorsely barbed and aid decidedly in helping the bur to hold on to one's toes or fingers and thus in being carried away from the favorable habitat of the parent plant to some possible, sterile ground where a cruel death may await the little sprouting embryos asleep within. Now, this bur is a very perfect device.

But there is still room for improvement, and the ideal is reached in such species as *Cenchrus palmeri* Vas. (Fig. 6) which has a very large prominently developed bur with large, long, stout prickles enclosing the spikelets with their ripe grain. Thus all these species and many others show a consistent orthogenetic movement from the very slight disturbance in the basal cortical development of *Chaetochloa verticillata* to *Cenchrus palmeri*. So far as the ability to get along in the world and to perpetuate itself are concerned, the last species is no better off than the first even though we have evolved a very ingenious structure to hold the seed as it comes from the parent plant. The first three important steps have no such use. So unless they were working for the good of the more highly perfected species of Cenchrus still to be evolved, it would be absurd to say that their first necessary steps were of any utility to themselves whatever. And there is also no evidence whatever that the elaborate bur is of any advantage to its possessor so far as a life and death struggle is concerned. For sandbur-grasses and foxtail-grasses grow side by side in the same field and the foxtails seem to be succeeding as well if not better than their neighbors with the perfect seed-holding device.

AN ORTHOGENETIC SERIES LEADING TO AN "ALABASTER BOX."

(See Plate II).

The Andropogoneæ, or beard-grasses, are even more extremely evolved than the panic-grasses just considered. It is, therefore, not surprising to find very remarkable peculiarities among them. The series which is outlined below represents the development of a box to hold the pair of spikelets and finally the mature grain. It is, in a broad sense, a device similar to the preceding case. But the box is produced by entirely different elements on a fundamentally different plan.

Many of the lower Andropogoneæ have quite ordinary panicles. The spikelets are in pairs, one stalked and one sessile. The specialization of these pairs of spikelets and their flowers presents a very interesting case of orthogenetic movement in itself in the various species series which will, however, not be considered here. In some of the less specialized genera, there is no special development of joints or abscission layers in the rachis below the pair of spikelets.

Passing from such species with continuous inflorescence branches, like *Miscanthus sinensis* Anderss., we come to forms represented by *Andropogon furcatus* Muhl. (Fig. 1) in which the branches of the inflorescence are very definitely jointed, and at maturity they are cut up into definite pieces by the formation of an abscission layer just below the insertion of the pair of sessile, grain bearing, and stalked, staminate spikelets. The rachis joint is slightly flattened on the side on which the spikelets are situated. Thus the first steps have been taken in the production of a typical crate for the grain in some future time and which may develop in some fortunate individuals which have advanced farther up the evolutionary ladder. The most important potentiality present is the ability to cut the material into suitable pieces at the proper places.

Figure 2 represents the rachis joint and spikelets of *Hemarthria fasciculata* (Law.) Kunth. The structure begins to have the first crude characteristics of a box. The rachis joint is flattened and somewhat excavated. The pedicel of the stalked spikelet is involved in this reäction and is usually grown to the edge of the rachis joint. The outer empty glume forms a respectable loose-fitting lid which is, however, too long for the box. The stalked spikelet is still entirely outside of the structure. In addition, another crude reaction which represents

a first step is evident in the articulation since the joints in Hemarthria are only tardily disarticulating. It is very commonly the case that both in important phylogenetic progressions as well as in trivial characters, the first steps are often imperfect, indefinite, or undependable. Just a little disturbance of the physiological states may cause either complete failure of the new hereditary expression or an imperfect expression. To find the promptness and decidedness of the abscission reaction, in contrast, one has only to go to the end of the series and examine a carpellate inflorescence of teosinte (Euchlaena).

Figure 3 represents a typical species of Coelorachis, *C. cylindrica* (Mx.) Nash. Here we have a box looking like the work of an amateur. The rachis is enlarged and deeply channeled; the abscission is definite; the stalked spikelet is greatly reduced and its flattened pedicel assists the lid in enclosing the fertile spikelet. The outer empty glume of the fertile spikelet is thickened and ornamented to some extent and forms an ill-fitting lid. The parts of the box fit better than the figure would indicate, since the "lid" and other glumes have been separated, for drawing, to show their nature more clearly. Other species of Coelorachis show the evolution of the box a little more perfected.

The gama-grass presents us with a well-evolved structure as shown in Fig. 4, *Tripsacum dactyloides* L. The rachis joints are enlarged and channeled out into deep troughs; the abscission is prompt and definite and the outer empty glume forms a well-fitting lid to close the opening; the carpellate spikelet with the mature gain is neatly boxed up. Were this structure about 10 times as long as it actually is, we could write an address on the side and, with the proper postage stamp, have it delivered through the mails to some distant office, confident in the fact that the parcel had been properly packed. Now the boxing up ability or potentiality has been properly attained by the adjustment and coordination of a large number of organs all of which had to evolve in the proper direction if the end result was to be attained. The box could be improved and beautified in various ways, however, and here we will find a principle at work that is of wide application in the entire realm of plant evolution. Evolution is above all perfective, and so cases are abundant where certain species have passed to this perfected ideal, often far beyond the limits of any real or imaginary

utility. There is no use of mincing words. These examples given are only selected cases out of great numbers of similar developments that any one can discover for himself if he is willing to spend 25 years of correct and intensive study in the taxonomy of plants.

The perfected box is attained in *Euchlaena mexicana* Schrad., or the teosinte, which stands at the limit of the Tripsacanæ subtribe in many other respects. Figure 5 is a drawing of the mature boxed-up carpellate spikelet of this grass. This is a true "alabaster box." Both the modified stem and the modified outer empty glume, which represent the box and its lid, are highly indurated into a hard, crustaceous polished substance and there are also ornamental blotches or mottelings in evidence while in Tripsacum no such ornamentation is in evidence. The whole box has been rounded off so that the crude rough edges, so prominent in Tripsacum, have been removed; the abscission surfaces, not visible in the drawing, have been contracted into comparatively small areas; the lid fits perfectly, and, *mirabile dictu*, is clamped down by the inrolling of the edges of the box. The point of perfection of workmanship has been attained. The spikelet with its grain is perfectly encased. Determinate evolution has about reached its limit. There is one further possibility. The surface, instead of being smooth, might be ornamented as often occurs in highly evolved, indurated structures. This actually did take place in some related genera which however, did not get quite as far in general as teosinte. As stated, ornamental markings are abundantly to be found in indurated seeds, fruits and other hard structures. In the higher plants, ornamentation is commonly an accompaniment of the evolutionary movement of induration. Now compare Fig. 1. with Fig. 5. and you have a picture of the real process of evolution. All the related species of the series can be arranged in an orthogenetic order, the various species having positions at various levels of advancement.

Teosinte grows side by side with Andropogons which have no alabaster boxes for their grains. So far as survival is concerned, one is as well off as the other. The box is of no use to its possessor in a life and death struggle for existence any more than a gold watch keeping very accurate time is of importance for the survival of a savage. Nevertheless it is an ingenious, pretty box useful for holding the grain. In dis-

covering the facts of orthogenetic series we are not concerned about the relation of one step to another, nor about the order of the appearance of the steps. These are propositions that can never have any direct proof except such as may be gleaned from the imperfect paleontological record. Our chief concern is in the validity of the series in closely related groups of species and when we have discovered this we know that although we may have difficulty in tracing the origin of these processes to their ultimate internal causes, we can rest on the convincing reality of the phenomena without being led into a belief of childishly superficial hypotheses as postulated in Lamarakism, in Darwinism, and in some of the more recently developed beliefs and fancies that would make of evolution a fortuitous process.

AN ORTHOGENETIC SERIES REPRESENTING THE EVOLUTION OF A POLLEN BRUSH.

(See Plate III. All the figures magnified on the same scale).

The relation of insects to pollination is quite generally known even among the non-scientific. In the dark ages of the last century, scientists and others firmly believed that the special adaptations to insects were evolved by natural selection through the survival of the fittest. The plant was under the necessity of being pollinated if a following generation was to inhabit the earth and it was assumed that there was some profound advantage in cross-pollination while selfing was supposed to be injurious enough to cause elimination in the long run. The implications seemed perfectly evident to the credulity of the supposedly critical biologists of the period. Now when we find that large numbers of species both in the wind pollinated and insect pollinated series, and especially many with elaborate mechanisms which seem especially devised to lure insects, are either cleistogamous or completely parthenogenetic, the whole hypothesis of the evolution of such structures being caused by the necessity of cross-pollination passes over into the realm of fairy tales. The lower undifferentiated species of flowers nearly always succeed in being pollinated while many which have extreme adaptations do so with difficulty. If one takes an inventory of an undifferentiated flower type like a crowfoot or an anemony he finds that ordinarily it is difficult to find a flower that is not pollinated, while some

extremely specialized flower like the common milkweed has about one chance in eighty. The higher forms usually develop zygomorphy and this with other movements reduces the supply of stamens and pollen per flower. But the same movement of reduction occurs in wind-pollinated series. The orthogenetic series here considered cannot be questioned. But when we ask for causal relations we find that at every step in the evolutionary process one type of individual is just as successful as the other. They all have survival value. The one without even a hint of the adaptation gets along just as well as the one which has developed it, to the extreme degree. The relation between the actual evolutionary process in the plant and the insects is no more evident than the relation of the flea to the dog on which it lives happily. Yet just as the flea could not exist without the dog environment so none of these plants of the given series could exist without the insects. The series presented is taken from the mint family. Essentially similar series, differing in details of structural development but not at all in the efficiency of the devices appear in many orders and families of flowering plants.

Figure 1 represents an ordinary type of stamen with no special peculiarities. It is a stamen of *Agastache scrophulariaefolia* (Willd.) Ktz. All the remaining 11 figures of plate III. show steps in the evolution of the structure under consideration. Since the drawings are all on the same scale, the evolution of both size and structure will be apparent as a progression toward perfection.

Figure 2 represents a stamen of *Teucrium occidentale* Gr. In this stamen something is at work which separates the two parts of the anther. Now, of course, no one in his rational senses would see in this minute device any advantage over the preceding in securing pollination, especially no survival value in a life and death struggle. But here we do have a new phylogenetic potentiality introduced with a very slight reaction. We could not predict whither it would lead unless we actually saw the series evolved through the operation of its orthogenetic property.

In figure 3, *Clinopodium vulgare* L., a considerable advance is shown in the enlargement of the connective between the two anther-sacs and in *Satureia hortensis* L. (Fig. 4) the anther-sacs are still farther apart. In *Monarda didyma* L. (Fig. 5) the connective has enlarged decidedly and in such a way that the

anther-sacs are completely divaricate. In the meantime it is evolving to a decidedly zygomorphic condition so that there are only two fertile stamens left. A further advance in the zygomorphic nature of the flower bud will involve the one anther-sac of each stamen. The peculiar potentiality which is separating the two anther-sacs to a greater or less extent in various genera and species in this region of the mint family has no direct relation to the development of zygomorphy itself but is an independent mutative manifestation. To claim that these slight changes in the contiguity of the anther-sacs and the enlargement of the connective had produced an advantage of any sort to the possessor would be the height of absurdity requiring the same kind of credulity as is necessary for a belief in fairy tales.

Now, if our orthogenetic perfecting principle is correct as shown in the evolution of the grain box in the Andropogoneæ, we may expect some interesting developments in case the evolutionary movement continues to its determinate limit; and since the rapid progression of zygomorphy of the flower is in evidence, this property will also be involved in the further enlargement and elongation of the connective. The genus Salvia represents about the extreme in the evolutionary progression of the flower in the Lamiaceæ, and fortunately there are about 500 species, so there is abundant opportunity for the orthogenetic series to reach the limit. *Salvia lyrata* L. (Fig. 6), although it has the connective enormously elongated, when compared with *Monarda didyma*, is nevertheless about the lowest of our native sages. From this species on the various Salvias fall into gradation series in respect to the lengthening of the anther connective until a very extreme development is reached. In *Salvia lyrata* the one arm of the connective with its anther-sac is much longer than the other. The anther-sac of the short arm is still functional but much reduced. This is due to the influence of the zygomorphic nature of the flower as a whole. The flower bud is evolving determinateness more rapidly on the one side than on the other. In this example we have the first prominent steps, which if continued will evolve a perfect lever-brush apparatus. That there is any advantage to the flower in the elongated connective and its one sided development with a consequent reduction in the amount of pollen available for pollination is not at all apparent. In fact if there is any effect which might influence survival, it

would have to be regarded as a decided disadvantage when compared with the first species given, belonging to Agastache, Teucrium, Clinopodium, and Satureia, all of which have 4 functional stamens although the flowers are all zygomorphic to a greater or less extent.

Figure 7 represents a stamen of the common sage, *Salvia officinalis* L. The movements which produced the stamen of *Salvia lyrata* are carried on further, so the connective is much longer and the reduced anther-sac is very small, approaching the vestigial condition. In *Salvia lanceifolia* Poir. (Fig. 8) the vestigial anther-sac has entirely disappeared and the entire connective is now in the form of a lever but still imperfectly developed. Figure 9 represents a stamen of *Salvia farinacea* Benth. In this form, any one can see a decided improvement over the last species; and *Salvia pitcheri* Torr. (Fig. 10) is a still further advance toward the ideal structure. In Pitcher's sage the brush and lever works very perfectly. In fact, so far as the ability of the mechanism to brush pollen on the insect's back is concerned, nothing more can be desired. But the orthogenetic, evolutionary movement can go farther still in the same direction, provided a lengthening factor appears to give the proper length of corolla tube. There is in the stamen mechanism itself nothing to place a definite limit to further advancement. So in *Salvia splendens* Ker-Gawl (Fig. 11) we find a much more extreme development of the mechanism, which was possible because of the introduction of a lengthening factor operative in the corolla and style. One would think that at this point the brush and lever mechanism had certainly attained the limit. But there is a further step possible. Not only can the length of the connective be augmented decidedly so long as the corolla and style continue to enlarge and elongate in their evolutionary course but with the advancement of the zygomorphic nature, there can be developed a decided difference between the brush arm and the handle arm of the lever. This is a simple principle of elementary mechanics. Now since the handle end of the lever necessarily projects down into the corolla tube, there is little room for movement even when it is pushed to the extreme limit. But if the arm of the lever which holds the anther-sac is decidedly lengthened then a small amount of movement at the handle will give a wide arc of movement in the brush end, which no doubt would facilitate the throwing out or sprinkling of the pollen on the back of the

visiting insect. This remarkable perfection is attained in *Salvia patens* Cav. (Fig. 12.).

Compare Fig. 6 with Fig. 12 and we are again passing from a crude beginning to the ultimate of perfection. Evolution is perfective. Yet there is no ecological advantage in all this. So far as a mechanism to insure pollination is concerned, *Agastache scrophulariaefolia* works just as perfectly as *Salvia lyrata* and this works just as well as *Salvia patens*. The matter of survival is not involved at all. Any one looking for such a condition is simply exercising his credulity in opposition to the biological facts and results. The insects involved were part of the environment while the evolution was taking place. Their presence made such an evolution possible but the ecological interaction was not the cause of the appearance of the special potentialities developed. We see that all the different steps in the process have survived because not a single change involved the problem of survival, and because evolution proceeds through individuals. Had the proper insects been completely eliminated from the environment there would have been no advance because of the ensuing struggle for perpetuation. The old alone would have remained; for the old continues as before. It is very important to grasp the significance of this fact. For none of the imaginary causal factors of evolution, reaction to environment, natural selection, use and disuse, or geographic barriers is in evidence. The only way in which environment enters into the problem is the fact that the environment holds efficient insect pollen carriers. Since the environment was thus present, the orthogenetic progression could proceed to the extreme limit of the extreme Salvias without encountering the factor of elimination. Without the proper environment the very first step, which made pollination dependent on the presence of certain kinds of insects, would have lead to destruction just as surely as the development of sterility in any individual line, whether plant, animal or human, necessarily brings an end of that particular line for all future time.

The three studies presented, which could easily be multiplied by the scores and hundreds, then plainly indicate that: Evolution is orthogenetic, perfective, and determinative.

EXPLANATION OF THE FIGURES OF PLATE I.

Fig. I. *Chaetochloa verticillata* (L.) Scribn., showing two retrorsely barbed bristles at the base of the pair of spikelets.

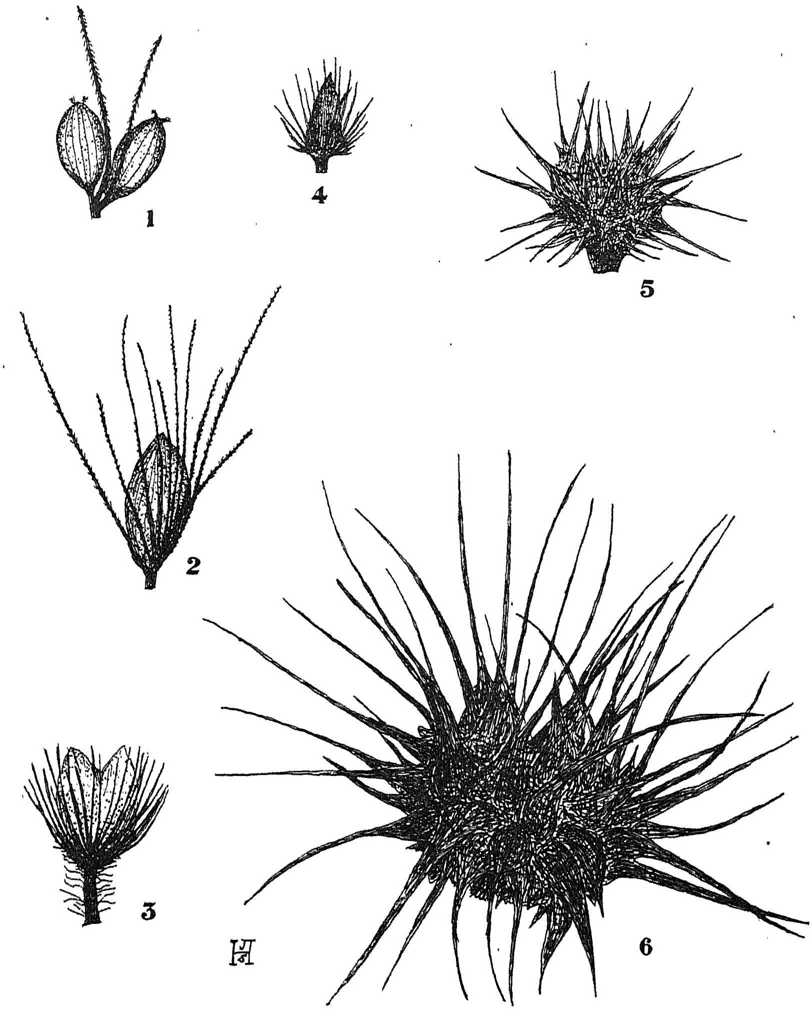
Fig. 2. *Chaetochloa imberbis* (Poir.) Scribn., with 10 bristles upwardly barbed.

Fig. 3. *Pennisetum glaucum* R. Br., with an involucre of stiff bristles and hairs around the expanded base of the pair of spikelets.

Fig. 4. *Cenchrus myosuroides* H. B. K., with a moderate development of the cortical expansion bearing a crown of prickles around the spikelets.

Fig. 5. *Cenchrus pauciflorus* Benth,. with a very pronounced cortical expansion and prominent prickles enclosing the two spikelets.

Fig. 6. *Cenchrus palmeri* Vas., with a very large development of the cortical expansion bearing large long prickles, the spikelets being entirely enclosed in this highly evolved bur.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EXPLANATION OF THE FIGURES OF PLATE II.

Fig. 1. *Andropogon furcatus* Muhl. A rachis joint with sessile and stalked spikelets.

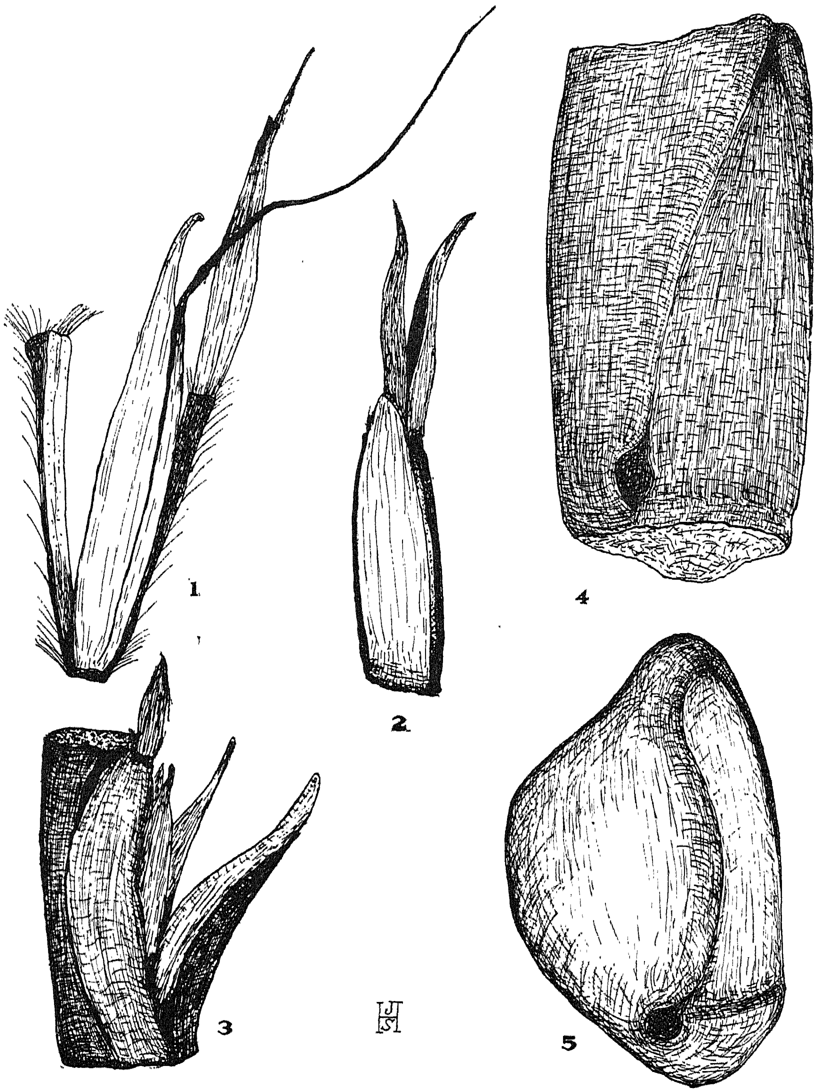
Fig. 2. *Hemarthria fasciculata* (Lam.) Kunth. Enlarged and slightly excavated rachis joint showing the stalk of the pedicellate spikelet united with its margin and the specialization of the outer empty glume of the sessile spikelet.

Fig. 3. *Coelorachis cylindrica* (Mx.) Nash. Deeply excavated and enlarged rachis joint showing the outer empty glume partly opened out to show the sessile spikelet and the stalked spikelet with vestigial glumes, situated at one side in front.

Fig. 4. *Tripsacum dactyloides* L. The highly evolved, enlarged and deeply excavated rachis joint showing the outer empty glume serving as a lid to the box and enclosing the spikelet with the grain.

Fig. 5. *Euchlaena mexicana* Schrad. Highly evolved, indurated, and perfected rachis joint enclosing the spikelets and grain completely, the indurated outer empty glume forming a closely fitting lid which is held down by the incurved edges of the box.

PLATE II.



EXPLANATION OF THE FIGURES OF PLATE III.

All the stamens are drawn to the same scale of magnification.

Fig. 1. *Agastache scrophulariaefolia* (Willd.) Ktz. An ordinary type of stamen with the two anther-sacs parallel and close together.

Fig. 2. *Teucrium occidentale* Gr., showing the anther-sacs somewhat divergent.

Fig. 3. *Clinopodium vulgare* L., showing the anther-sacs separated by the broadening of the connective.

Fig. 4. *Satureia hortensis* L. The anther-sacs are still farther apart.

Fig. 5. *Monarda didyma* L., showing a very prominent development of the connective with the anther-sacs divaricate.

Fig. 6. *Salvia lyrata* L., showing the connective greatly elongated, appearing like a cross-bar between the two anther-sacs, the one of which is becoming vestigial because of the evolution of zygomorphy.

Fig. 7. *Salvia officinalis* L. A more extreme development of the connective between the two anther-sacs, the one of which is decidedly reduced.

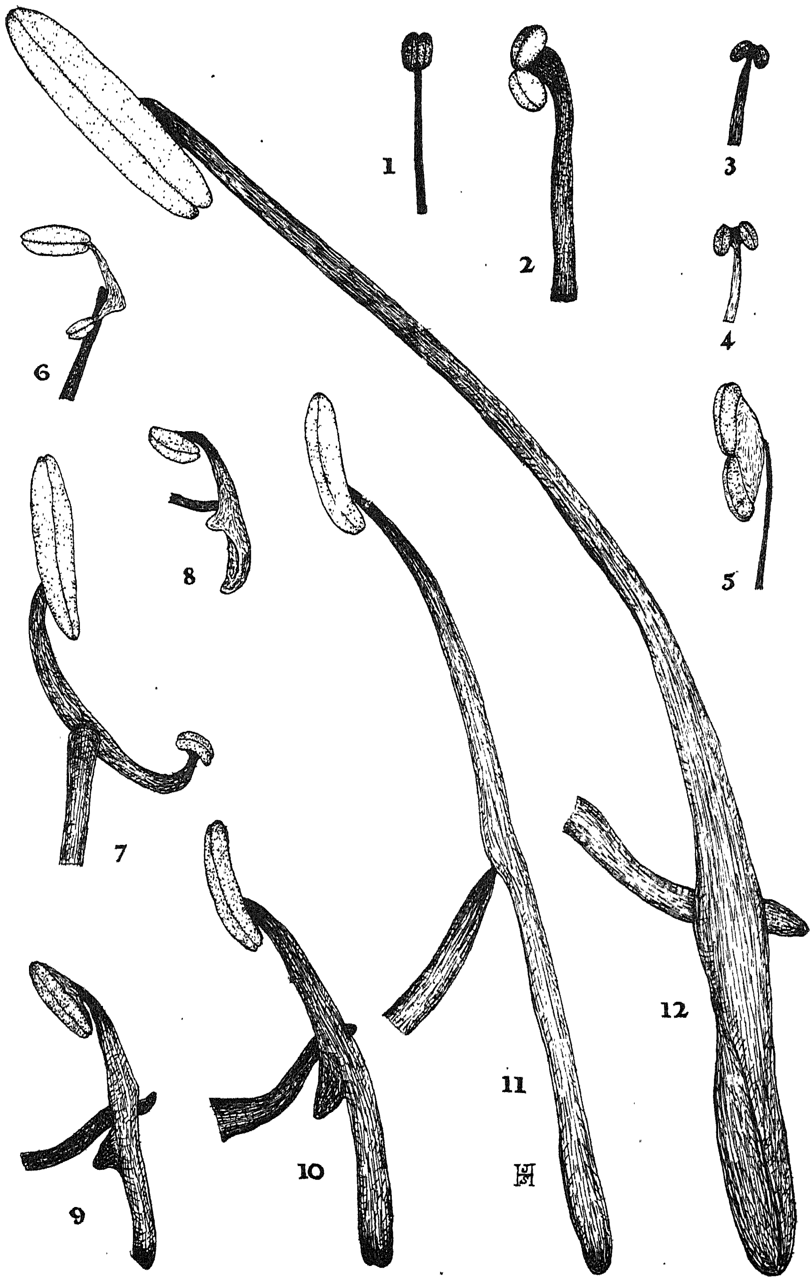
Fig. 8. *Salvia lanceifolia* Poir. The connective has evolved into a well developed lever-bar and the vestigial anther-sac has disappeared.

Fig. 9. *Salvia farinacea* Benth. The connective is longer and the handle end is more perfectly developed.

Fig. 10. *Salvia pitcheri* Torr. The connective is still longer and the apparatus works as an ingenious pollination device.

Fig. 11. *Salvia splendens* Ker-Gawl. The stamen has an enormously long connective, fitting with the long corolla tube.

Fig. 12. *Salvia patens* Cav. The connective is not only much longer than in any of the preceding but the brush end of the lever is very much longer than the handle end.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A KEY TO THE SPECIES, VARIETIES, AND FORMS OF THE ALGAL GENUS ŒDOGONIUM*.

L. H. TIFFANY,
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Although the writer has in an advance state of preparation a complete monographic report of the algal genus Oedogonium, it seems appropriate to present at this time a key to all forms known, together with a few notes on some recent changes and additions to the taxonomic nomenclature of the genus. It is candidly admitted at the outset that any key not illustrated is well-nigh "an abomination unto science." It is equally true, on the other hand, that an attempt to include all the species, varieties, and forms of a genus as large as Oedogonium into a workable key is not without its difficulties. A very earnest effort has been made to examine all the literature pertinent to the subject. In all probability some species have been omitted. The writer will appreciate very much having his attention called to any members of the genus not included herewith. In fact, any correction or suggestion regarding the key and its workability will be most welcome; thus, a preliminary report seems desirable.

The key has been made with the deliberate aim of helping the student of the genus to name his collection. Morphological relationships have been severed whenever it was felt that the alga could be identified more readily in another association. The key has been considerably revised since its first draft nearly six years ago, and the writer is grateful to his students and colleagues for their constructive criticisms. If the name of the alga is followed by an asterisk, it signifies that the description is incomplete and hence the position in the key only a probability.

* Papers from the Department of Botany, the Ohio State University, No. 232.

THE KEY.

1. Vegetative cell undulate or nodulose.................................... 2
1. Vegetative cell punctate or granulate.................................... 6
1. Vegetative cell distinctly capitellate.................................... 7
1. Vegetative cell cylindrical.................................... 35
1. Vegetative cell subhexagonal or subellipsoid............*Oe. reinschii**
    2. Without dwarf male.................................... 3
    2. With dwarf male.................................... 4
3. Diameter of oogonium 18–23μ..........................*Oe. sphaerandrium*
3. Diameter of oogonium 48–57μ..........................*Oe. nodulosum*
3. Diameter of oogonium 64–74μ...............*Oe. nodulosum* var. *commune*
    4. Diameter of oogonium 44–56μ.................................... 5
    4. Diameter of oogonium 58–68μ.........*Oe. undulatum* var. *americanum*
5. Dwarf male 36–46μ in length................*Oe. undulatum* f. *senegalense*
5. Dwarf male 48–70μ in length..........................*Oe. undulatum*
    6. Diameter of vegetative cell 6–8μ.................*Oe. elegans*
    6. Diameter of vegetative cell 9–13μ................*Oe. minus*
    6. Diameter of vegetative cell 16–22μ...............*Oe. punctatostriatum*
7. Without dwarf male.................................... 8
7. With dwarf male.................................... 17
7. Reproductive structures imperfectly known.................................... 34
    8. Dioecious.................................... 9
    8. Monoecious.................................... 11
9. Division of oogonium basal............................*Oe. infimum*
9. Division of oogonium inferior..........................*Oe. inversum*
9. Division of oogonium median.................................... 10
    10. Oogonium 26–29μ in diameter.........*Oe. howardii* var. *minus*
    10. Oogonium 29–32μ in diameter....................*Oe. howardii*
    10. Oogonium 32–36μ in diameter....................*Oe. latiusculum*
11. Oogonium opening by a pore................*Oe. hirnii* var. *africanum*
11. Oogonium opening by a lid.................................... 12
    12. Diameter of oogonium 15–25μ.................................... 13
    12. Diameter of oogonium 34–46μ.................................... 16
13. Division of oogonium median.................................... 14
13. Division of oogonium supramedian.................................... 15
    14. Oogonium subdepressed-globose.................*Oe. capitellatum*
    14. Oogonium angular-globose.......................*Oe. quadratum*
15. Diameter of oogonium 15–20μ..........................*Oe. virceburgense**
15. Diameter of oogonium 18–23μ..........................*Oe. sphaerandrium*
15. Diameter of oogonium 26–29μ..........................*Oe. spurium**
    16. Vegetative cell punctate........................*Oe. minus*
    16. Vegetative cell not punctate.....................*Oe. bohemicum*
17. Poriferous...*Oe. nebraskense*
17. Operculate.................................... 18
    18. Division of oogonium median.................................... 19
    18. Division of oogonium supramedian.................................... 24
    18. Division of oogonium inframedian.................................... 26
    18. Division of oogonium superior..................*Oe. rigidum*
    18. Division of oogonium supreme.................................... 29
19. Division of oogonium narrow.................................... 20
19. Division of oogonium wide.................................... 21
    20. Oogonium 28–35 × 23–38μ............*Oe. decipiens* f. *dissimile*
    20. Oogonium 46–54 × 44–54μ.......................*Oe. bengalense*
    20. Oogonium 57–64 × 48–53μ.......................*Oe. indicum*
21. Diameter of oospore 22–26μ.................................... 22
21. Diameter of oospore 30–32μ................*Oe. areschougii* f. *robustum*
21. Diameter of oospore 42–48μ.................................... 23
21. Diameter of oospore 48–53μ..........................*Oe. brasiliense*
    22. Gynandrosporous..............................*Oe. areschougii*
    22. Idioandrosporous....................*Oe. areschougii* var. *americanum*
23. Vegetative cell 14–19μ in diameter....................*Oe. bengalense*
23. Vegetative cell 19–26μ in diameter....................*Oe. confertum*

24. Diameter of oogonium 14–26μ.................... *Oe. clavatum*
24. Diameter of oogonium 27–42μ.................................. 25
24. Diameter of oogonium 50–55μ.................... *Oe. costatum*
24. Diameter of oogonium 58–65μ.................... *Oe. boreale*
25. Oogonium 19–25μ in length.................. *Oe. oelandicum* f. *minus*
25. Oogonium 25–32μ in length............................ *Oe. oelandicum*
25. Oogonium 40–45μ in length............................ *Oe. megaporum*
26. Suffultory cell enlarged .... *Oe. platygynum* var. *continuum*
26. Suffultory cell not enlarged.. 27
27. Diameter of vegetative cell 6–10μ.. 28
27. Diameter of vegetative cell 12–15μ.................... *Oe. bahusiense*
28. Gynandrosporous only................ *Oe. platygynum* var. *novæzelandiæ*
28. Idioandrosporous only................ *Oe. platygynum* f. *obtusum*
28. Gynandrosporous and idioandrosporous........... *Oe. platygynum*
29. Oospore wall smooth.. 30
29. Oospore wall longitudinally ribbed..................... *Oe. michiganense*
30. Idioandrosporous.. 31
30. Gynandrosporous.. 32
31. Oogonium 48–60 × 62–74μ............................ *Oe. praticolum*
31. Oogonium 66–78 × 72–90μ............................ *Oe. supremum*
32. Diameter of oogonium 36–42μ.................... *Oe. wabashense*
32. Diameter of oogonium 42–55μ.. 33
32. Diameter of oogonium 55–58μ......... *Oe. obtruncatum* var. *completum*
33. Length of oogonium 56–68μ.......................... *Oe. obtruncatum*
33. Length of oogonium 68–75μ................ *Oe. obtruncatum* var. *ellipsoideum*
34. Vegetative cell 2–3μ in diameter................. *Oe. fusus**
34. Vegetative cell 4–6μ in diameter................. *Oe. virceburgense**
34. Vegetative cell 6–13μ in diameter................ *Oe. spurium**
35. Diameter of vegetative cell not more than 2μ........... *Oe. angustissimum**
35. Diameter of vegetative cell 2–60μ.. 36
35. Diameter of vegetative cell 64–93μ.. 268
36. Without dwarf males.. 37
36. With dwarf males.. 186
37. Oogonium opening by a pore.. 38
37. Oogonium opening by a lid.. 139
38. Pore median.. 39
38. Pore supramedian (rarely varying to superior).................... 51
38. Pore superior.. 63
39. Wall of oospore smooth.. 40
39. Wall of oospore scrobiculate.. 49
39. Wall of oospore echinate.. 50
40. Monoecious.. 41
40. Dioecious.. 44
41. Diameter of oogonium 18–28μ.. 42
41. Diameter of oogonium 32–38μ........................ *Oe. laeve*
42. Filament irregularly curved.................... *Oe. curvum*
42. Filament straight.. 43
43. Oogonium 23–28 × 26–31μ............................ *Oe. cryptoporum*
43. Oogonium 18–25 × 18–26μ.................. *Oe. cryptoporum* var. *vulgare*
44. Diameter of oogonium 22–27μ.. 45
44. Diameter of oogonium 27–32μ.. 47
44. Diameter of oogonium 30–39μ.. 48
45. Diameter of vegetative cell 5–10μ.. 46
45. Diameter of vegetative cell 8–13μ........... *Oe. rufescens* var. *lundellii*
46. Diameter of vegetative cell 5–9μ...... *Oe. rufescens* f. *exiguum*
46. Diameter of vegetative cell 8–10μ............... *Oe. rufescens*
47. Diameter of vegetative cell 9–11μ........... *Oe. inerme* var. *mentiens**
47. Diameter of vegetative cell 11–14μ.................... *Oe. calcareum*
48. Oospore 28–35 × 28–35μ........................ *Oe. sociale*
48. Oospore 33–38 × 28–32μ........................ *Oe. inerme**
49. Monoecious.. *Oe. cymatosporum*
49. Dioecious (very rarely monoecious).................... *Oe. magnusii*

50. Diameter of vegetative cell 9–14μ .... *Oe. suecicum*
50. Diameter of vegetative cell 14–16μ .... *Oe. suecicum* f. *australe*
51. Wall of oospore smooth 52
51. Wall of oospore scrobiculate .... *Oe. moniliforme**
52. Monoecious 53
52. Dioecious 58
52. Both monoecious and dioecious .... *Oe. varians*
53. Pore a little above median 54
53. Pore nearly superior 56
53. Pore variable between these two positions 57
54. Diameter of oogonium 34–45μ 55
54. Diameter of oogonium 46–55μ .... *Oe. urbicum*
55. Oospore depressed-globose, 30–34 × 28–32μ .... *Oe. obsoletum*
55. Oospore regularly globose, 30–39 × 30–39μ .... *Oe. plusiosporum*
56. Oospore 31–41 × 30–41μ .... *Oe. varians*
56. Oospore 40–48 × 40–48μ .... *Oe. tyrolicum*
57. Terminal cell narrowed and often setiferous .... *Oe. inflatum**
57. Terminal cell neither narrowed nor setiferous .... *Oe. urbicum*
58. Pore a little above median 59
58. Pore nearly superior 60
58. Pore variable between these two positions 62
59. Vegetative cell 1–3 diameters long .... *Oe. cardiacum* f. *pulchellum*
59. Vegetative cell 3–7 diameters long .... *Oe. cardiacum*
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138. Length of oogonium 48–70μ.......................*Oe. americanum*
138. Length of oogonium 81–113μ.......................*Oe. taphrosporum*

WITHOUT DWARF MALES, OPERCULATE OOGONIUM, CYLINDRICAL VEGETATIVE CELLS.

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NOTES ON NEW FORMS.

In analyzing the members of the genus *Oedogonium* it seems necessary in the interest of completeness and simplicity to recognize the new forms and combinations described below. Insofar as the notes of the writer are complete, this brings the genus up to date.

Oe. borisianum (Le Cl.) Wittr. var. *westii* Tiffany & Brown, nov. var.
Oe. Borisianum (Le Cl.) Wittr. *in* West and West, 1903, p. 36.

Larger dimensions throughout; vegetative cell 17–19 × 130–180μ; suffultory cell 31–42 × 105–168μ; oogonium 53–60 × 67–88μ; oospore 49–58 × 49–58μ; antheridium 17 × 12–13μ.

England; Mississippi (U. S. A.)

Oe. decipiens Wittr. var. *africanum* nov. var.
Oe. decipiens forma West and West, 1897, p. 5; Hirn, 1900, p. 267, Pl. XLVI, Fig. 284.

A little smaller than the type and idioandrosporous; vegetative cell 8–13 × 25–60μ; oogonium 25–32 × 24–32μ; oospore 24–30 × 23–28μ; androsporangium 7–11 × 9–13μ; dwarf male 6–7 × 9–12μ.

Africa.

Oe. dictyosporum Wittr. f. *westii* nov. f.
Oe. dictyosporum Wittr. *forma* West, 1907, p. 98.

Oogonium and oospore ovate-ellipsoid, a little larger than the type; vegetative cell 14–16 × 50–80μ; oogonium 42 × 52μ; oospore 40 × 50μ; antheridium 13 × 8–9μ.

Africa.

Oe. hystrix Wittr. var. *canadense* nov. var.
(?) *Oe. hystrix* Wittr. *in* Skuja, 1927, Pl. II, Fig. 13.

Pore inframedian; vegetative cell 14–25 × 80–125μ; suffultory cell 24–30 × 64–72μ; oogonium 40–53 × 52–64μ; oospore 38–48 × 40–60μ; androsporangium 16–20 × 15–30μ; antheridium 7–8 × 8–14μ; dwarf male stipe 9–12 × 28–40μ.

All of the individual plants of *Oe. hystrix* that I have seen had the median pore as a very constant characteristic. In material sent me by Mr. G. H. Wailes from British Columbia occurred a form along with the type, having the pore uniformly below the median position. This together with differences in size seems to warrant a new variety. The form figured by Skuja very probably should be referred to this variety, although the dimensions are not quite the same.

British Columbia; (?) Latvia.

Oe. intermedium Wittr. var. *fennicum* nov. var.
Oe. intermedium Wittr. *forma valida* Hirn, 1900, p. 95, Pl. V, Fig. 32; *Oe. intermedium* Wittr. *forma* West, 1909, p. 239.

Oogonium and oospore considerably larger; vegetative cell 17–19 × 50–120μ; oogonium 38–46 × 42–60μ; oospore 35–40 × 35–40μ; antheridium 13–18 × 6–8μ.

Finland; Egypt; Michigan (U. S. A.).

Oe. macrandrium Wittr. var. *hohenackerii* (Wittr.) nov. comb.

Oe. Hohenackerii Wittrock, 1874, p. 23; *Oe. tumidulum* in *Hohenacker* Alg. Exs. No. 404; *Oe. Hohenackerii* Wittr. *in* Hirn, 1900, p. 238, Pl. XL, Fig. 246.

Vegetative cell 12–15 × 24–45μ; oogonium 29–33 × 30–35μ; oospore 27–31 × 28–31μ; androsporangium 11–13 × 10–14μ; dwarf male stipe 9–14 × 18–24μ; antheridium 5–6 × 5–8μ.

A collection of this interesting member of the genus from Michigan by Miss Alma B. Ackley helped to establish definitely that it belongs with the *macrandrium* group. Its shorter vegetative cells constitute its chief distinctive characteristic, but it seems to occur regularly.

India; Massachusetts and Michigan (U. S. A.).

Oe. rufescens Wittr. var. *lundellii* (Wittr.) nov. comb.

This variety was originally described by Wittrock (1872, p. 32) as *Oe. Lundellii*. It is considered as a subspecies of *Oe. rufescens* by Hirn (1900, p. 77, Pl. I, Fig. 6). It clearly belongs with *rufescens*, but I can see no necessity of maintaining the division "subspecies" in the nomenclature of the genus. Its dimensions are very near those of the species proper, but its slightly wider vegetative cells in proportion to oogonia and the depressed-globose appearance of the oogonia, which are quite constant, perhaps warrant a varietal rank.

Oe. spirale Hirn var. *latviense* nov. var.

Oe. spirale Hirn f. in Skuja, 1927, p. 102, Pl. II, Fig. 14, a, b.

Pore supramedian or superior; vegetative cell 16–20 × 65–120μ; oogonium 49–60 × 65μ; oospore (without ribs) 35–45 × 35–45μ, not filling oogonium, outer wall with 5 to 6 spirally arranged ribs; dwarf male 12 × 50μ.

The above description of the alga, as given by Skuja for the Latvian material, seems to warrant varietal rank.

Latvia.

Oe. capilliforme Kuetz.; Wittr. var. *diversum* (Hirn) nov. comb.

Oe. capilliforme Kuetz.; Wittr. var. *australe* Wittr. f. *diversum*, Hirn, 1900, p. 110, Pl. IX, Fig. 54; *Oe. stagnale* Kuetz. *in* Tilden Amer. Algæ, 1896.

Dimensions larger throughout; female vegetative cell 34–46 × 45–130μ; male vegetative cell 33–40 × 50–120μ; oogonium 46–56 × 46–70μ; oospore 43–52 × 40–58μ; antheridium 30–37 × 6–11μ.

U. S. A.: Colorado, Iowa.

ALPHABETICAL LIST OF SPECIES, VARIETIES, AND FORMS.

The following is a complete list of all members of *Oedogonium* thought to have a tenable position in the genus. A few species with very incomplete and unsatisfactory descriptions are not included. They will be discussed in the monographic report.

In working through a genus as large as *Oedogonium*, one finds it quite difficult to pass on the validity of some members. Such decisions, while always influenced to some extent by personal interpretations, must rest upon one's knowledge of all species and their variations.

The ultimate criterion must be the constancy of such characteristics as methods of reproduction, size (within limits), shape of cells, opening of oogonia, etc. How much are all these altered by ecological conditions of the body of water in which the algæ are growing? Unfortunately our data here are far from complete. When one finds a combination of the same characteristics in a given alga year after year in various habitats, one can be reasonably sure of the constancy of the species.

If an alga occurs year after year in the same habitat with a known species, differing in one or more morphological characteristics but evidently closely related to the type, it should be classed as a "variety." As an example, the robust variety (*majus*) of *Oe. grande* has been collected with the type in nearly all collections from the United States. Such differences can hardly be accounted for on the basis of environmental influences.

The category "form" ("forma" of Hirn) should be regarded as a temporary disposition only. If an alga varies from the description of a given species and has been seen only once or twice, it is hardly possible to know whether the variation is constant or merely an ecological variation. If the form occurs with the type and is found on several occasions to maintain its morphological variation, it should be raised to varietal rank. A "form" then should be retained only when the data are insufficient to pass on the constancy of the variations noted in the description.

The following list is based on the above interpretation.

1. *acmandrium* Elfv.
2. *acrosporum* De Bary.
3. " f. *boreale* (Wolle) Hirn.
4. " var. *bathmidosporum* (Nord.) Hirn.
5. *acrosporum* var. *floridense* Wolle.
6. " var. *majusculum* Nordst.
7. *ahlstrandii* Wittr.
8. *alternans* Wittr. & Lund.
9. *americanum* Transeau.
10. *angustissimum* West & West.
11. *anomalum* Hirn.
12. *arcyosporum* Nor. & Hirn.
13. *areolatum* Lagerheim.
14. *areschougii* Wittr.
15. " var. *americanum* Tiffany
16. " f. *robustum* Hirn.
17. *argenteum* Hirn.
18. *armigerum* Hirn.
19. *aster* Wittr.
20. *australianum* Hirn.
21. *autumnale* Wittr.
22. *bahusiense* Nordst.
23. *bengalense* Hirn.
24. *biforme* Nordst.
25. *bohemicum* Hirn.
26. *boreale* Hirn.
27. *borisianum* (Le Cl.) Wittr.
28. " var. *westii* Tiffany & Brown.
29. *boscii* (Le Cl.) Wittr.
30. *boscii* (Le Cl.) Wittr. f. *dispar* Hirn.
31. " var. *notabile* Lemm.
32. " var. *occidentale* Hirn.
33. *brasiliense* Borge.
34. *braunii* Kuetz.; Pringsh.
35. " var. *hafniense* (Hallas) Hirn.
36. " var. *zehneri* Tiffany.
37. *calcareum* Cleve.
38. *capense* Nordst. & Hirn.
39. *capillare* (L.) Kuetz.
40. " f. *stagnale* (Ktz.; Wittr.) Hirn.
41. *capilliforme* Kuetz.; Wittr.
42. " f. *debaryanum* (Chmiel.) Hirn.
43. *capilliforme* f. *lorentzii* (M. & W.) Hirn.
44. *capilliforme* var. *australe* Wittr.
45. " var. *diversum* (Hirn) Tiffany.
46. *capitellatum* Wittr.
47. *cardiacum* (Hass.) Wittr.
48. " f. *interjectum* Hirn.
49. " f. *pulchellum* (Hass.) Hirn.
50. " var. *carbonicum* Wittr.
51. " var. *minor* Lemm.
52. *cataractum* Wolle.
53. *ciliatum* (Hass.) Pringsh.
54. *clavatum* Hallas.
55. *cleveanum* Wittr.
56. " f. *exoticum* Hirn.
57. *concatenatum* (Hass.) Wittr.
58. *concatenatum* f. *hutchinsiæ* (Wittr.) Hirn.
59. *concatenatum* var. *rectangulare* Rich.
60. *confertum* Hirn.
61. *consociatum* Collins & Hervey.
62. *contortum* Hallas.
63. *costatum* Transeau, Mss.
64. *crassiusculum* Wittr.
65. " var. *arechavaletæ* (Wittr.) Hirn.
66. *crassiusculum* var. *idioandrosporum* Nor. & Wtr.
67. *crassum* (Hass.) Wittr.
68. " f. *amplum* (Magnus & Wille) Hirn.
69. *crassum* var. *longum* Transeau.
70. " var. *subtumidum* Hirn.
71. *crenulatocostatum* Wittr.
72. " f. *cylindricum* Hirn.
73. *crenulatocostatum* var. *aureum* Tilden.
74. *crenulatocostatum* var. *longiarticulatum* Hansg.
75. *crenulatum* Wittr.
76. " var. *gracilius* (Nordst.) Hirn.
77. *crispum* (Hass.) Wittr.
78. " f. *granulosum* (Nordst.) Hirn.
79. *crispum* f. *inflatum* Hirn.
80. " var. *gracilescens* Wittr.
81. " var. *hawaiense* Nordst.
82. " var. *uruguayense* Magnus & Wille.
83. *cryptoporum* Wittr.
84. " var. *vulgare* Wittr.
85. *curtum* Wittr. & Lund.
86. *curvum* Pringsheim.
87. *cyathigerum* Wittr.
88. " f. *americanum* Wolle.
89. " f. *ornatum* (Wittr.) Hirn.
90. *cyathigerum* f. *perfectum* Hirn.
91. " var. *ellipticum* M. & W.
92. " var. *hormosporum* (West) Hirn.
93. *cymatosporum* Wittr. & Nordst.
94. *danicum* Hallas.
95. *decipiens* Wittr.
96. " f. *dissimile* Hirn.
97. " var. *africanum* Tiffany.
98. " var. *bernardense* (Bates) Hirn.
99. *depressum* Pringsh.
100. *dictyosporum* Wittr.
101. " f. *westii* Tiffany.
102. *dioicum* Carter.
103. *donnellii* Wolle; Hirn.
104. " var. *wittrockiana* Hirn.
105. *echinatum* (Wood) Wittr.
106. *echinospermum* Al. Br.
107. " var. *horridum* Hirn.

108. *elegans* West & West.
109. *excisum* Wittr. & Lund.
110. *exocostatum* Tiffany.
111. *exospirale* Tiffany.
112. *fabulosum* Hirn.
113. " var. *maximum* (West) Hirn.
114. *fabulosum* var. *punctatum* Lemm.
115. *flavescens* (Hass.) Wittr.
116. *flexuosum* Hirn.
117. *fonticola* Al. Braun.
118. *foveolatum* Wittr.
119. *fragile* Wittr.
120. " var. *abyssinicum* Hirn.
121. *franklinianum* Wittr.
122. *fusus* Hallas.
123. *gallicum* Hirn.
124. *geniculatum* Hirn.
125. *giganteum* Kuetz.; Wittr.
126. *glabrum* Hallas.
127. *globosum* Nordst.
128. *gracillimum* Wittr. & Lund.
129. " f. *majus* West & West.
130. *grande* Kuetz.; Wittr.
131. " f. *gemelliparum* (Pring).Hirn.
132. " var. *aequatoriale* Wittr.
133. " var. *angustum* Hirn.
134. " var. *majus* Hansg.
135. *gunnii* Wittr.
136. *hians* Norst. & Hirn.
137. *hirnii* Gutwinski.
138. " var. *africanum* G. S. West.
139. *hispidum* Nordst.
140. *hoehnei* Borge.
141. *hoersholmiense* Hallas.
142. *howardii* G. S. West.
143. " var. *minus* Tiffany.
144. *huntii* Wood.
145. *hystricinum* Transeau & Tiffany.
146. *hystrix* Wittr.
147. " var. *canadense* Tiffany.
148. " var. *subglobosum* Wittr.
149. *illinoiense* Transeau.
150. *implexum* Hirn.
151. *inconspicuum* Hirn.
152. *indicum* Hirn.
153. *inerme* Hirn.
154. " var. *mentiens* Hirn.
155. *infimum* Tiffany.
156. *inflatum* Hallas.
157. *insigne* Hirn.
158. *intermedium* Wittr.
159. " var. *fennicum* Tiffany.
160. *inversum* Wittr.
161. *iowense* Tiffany.
162. *irregulare* Wittr.
163. " var. *condensatum* (Hallas) Hirn.
164. *itzigsohnii* De Bary.
165. " f. *heteromorphum* Hirn.
166 " var *minus* West.
167. *kirchneri* Wittr.
168. *kitutæ* G. S. West.
169. *kjellmanii* Wittr.; Hirn.
170. *kurzii* Zeller.
171. *laetevirens* Wittr.
172. *laeve* Wittr.
173. *lageniforme* Hirn.
174. *lagerstedtii* Wittr.
175. *landsboroughi* (Hass.) Wittr.
176. " var. *norvegicum* Wittr.
177. *latiusculum* Tiffany.
178. *lautumniarum* Wittr.
179. *leiopleurum* Nordst. & Hirn.
180. *lindmanianum* Wittr.
181. *longatum* Kuetz.
182. *longicolle* Nordst.; Hirn.
183. " var. *senegalense* Nordst.
184. *loricatum* Hirn.
185. *macrandrium* Wittr.
186. " f. *acuminatum* Hirn.
187. " f. *aemulans* Hirn.
188. " f. *lundense* (Wittr.) Hirn.
189. *macrandrium* var. *propinquum* (Wittr.) Hirn.
190. *macrandrium* var. *hohenackerii* (Wittr.) Tiffany.
191. *macrandrium* var. *scrobiculatum* Ackley, Mss.
192. *macrospermum* West & West.
193. *magnusii* Wittr.
194. *mammiferum* Wittr.; Nordst.
195. *manschuricum* Skvortzow.
196. *margaritiferum* Nordst. & Hirn.
197. *martinicense* Hirn.
198. *megaporum* Wittr.; Hirn.
199. *mexicanum* Wittr.
200. *michiganense* Tiffany.
201. *minus* Wittr.
202. *mirandrium* Skuja.
203. *mitratum* Hirn.
204. *monile* Berk. & Harv.; Wittr.
205. " f. *borgei* Hirn.
206. " var. *eminens* Hirn.
207. " f. *victoriense* G. S. West.
208. *moniliforme* Wittr.
209. *montagnei* Fiorini-Mazzanti; Wittr.
210. *multisporum* Wood.
211. " var. *magnum* Ackley, Mss.
212. *nanum* Wittr.; Tiffany.
213. *nebraskense* Ohashi.
214. *nobile* Wittr.
215. " var. *minus* Hirn.
216. *nodulosum* Wittr.
217. " var. *commune* Hirn.
218. *obesum* (Wittr.) Hirn.
219. *oblongellum* Kirch.
220. *oblongum* Wittr.
221. " f. *majus* (Nordst.) Hirn.
222. " f. *sphaericum* (Hallas) Hirn.
223. *oboviforme* Wittr.
224. *obsoletum* Wittr.

225. *obtruncatum* Wittr.
226. " var. *completum* Hirn.
227. " var. *ellipsoideum* Wittr.
228. *oelandicum* Wittr.
229. " f. *minus* Borge.
230. *oryzæ* Wittr.
231. " var. *seriosporum* (Lager.) Hirn.
232. *oviforme* (Lewin) Hirn.
233. *pachyandrium* Wittr.
234. *pachydermum* Wittr. & Lund.
235. *paludosum* (Hass.) Wittr.
236. " var. *americanum* Nordst.
237. " var. *parvisporum* Hirn.
238. *paucocostatum* Transeau.
239. " var. *gracilis* Tiff.
240. *paulense* Nordst. & Hirn.
241. *perspicuum* Hirn.
242. *petri* Wittr.
243. *pisanum* Wittr.
244. " var. *gracilis* Trans. & Tiff.
245. *pithophoræ* Wittr.
246. *plagiostomum* Wittr.
247. " var. *gracilius* Wittr.
248. *platygynum* Wittr.
249. " f. *obtusum* Hirn.
250. " var. *continuum* Nordst.
251. " var. *novæ zelandiæ* Hirn.
252. *plicatulum* Wittr.
253. *plusiosporum* Wittr.
254. *pluviale* Nordst.
255. *poecilosporum* Nordst. & Hirn.
256. *porrectum* Nordst. & Hirn.
257. *pratense* Transeau.
258. *praticolum* Transeau.
259. *princeps* (Hass.) Wittr.
260. *pringsheimii* Cramer; Wittr.
261. " var. *abbreviatum* Hirn.
262. *pringsheimii* var. *nordstedtii* Wittr.
263. *psaegmatosporum* Nordst.
264. *pseudacrosporum* Wittr.
265. *pseudoboscii* Hirn.
266. *pulchrum* Nordst. & Hirn.
267. *punctatostriatum* De Bary.
268. *punctatum* Wittr.
269. *pungens* Hirn.
270. *pusillum* Kirchner.
271. *pyriforme* Wittr.
272. *pyrulum* Wittr.
273. *quadratum* Hallas.
274. *reinschii* Roy.
275. *rhodosporum* (Welwitsch) Wittr.
276. *richterianum* Lemm.
277. *rigidum* Hirn.
278. *rivulare* (Le Cl.) Al. Br.
279. *rothii* (Le Cl.) Pringsheim.
280. *rufescens* Wittr.
281. " f. *exiguum* (Elfving) Hirn.
282. " var. *lundellii* (Wittr.) Tiff.
283. *rugulosum* Nordst.
284. " f. *minutum* (Hansg.), Hirn.
285. *rugulosum* f. *rotundatum* Hirn.
286. *rupestre* Hirn.
287. " f. *pseudautumnale* Hirn.
288. *sancti thomæ* Wittr. & Cleve.
289. *schmidlei* Gutwinski.
290. *scrobiculatum* Wittr.
291. *selandiæ* Hallas.
292. *semiapertum* Nordst. & Hirn.
293. *sexangulare* Cleve.
294. " var. *angulosum* (Hallas) Hirn.
295. *sexangulave* var. *majus* Wille.
296. *silvaticum* Hallas.
297. *simplex* Hirn.
298. *sociale* Wittr.
299. *sodiroanum* Lagerheim.
300. *sol* Hirn.
301. *spectabile* Hirn.
302. *sphaerandrium* Wittr. & Lund.
303. *spirale* Hirn.
304. " var. *acutum* G. S. West.
305. " var. *latviense* Tiffany.
306. *spurium* Hirn.
307. *stellatum* Wittr.
308. *suboctangulare* G. S. West.
309. *subrectum* Hirn.
310. *suecicum* Wittr.
311. " f. *australe* G. S. West.
312. *supremum* Tiffany.
313. *tapeinosporum* Wittr.
314. *taphrosporum* Nordst. & Hirn.
315. *tentoriale* Nordst. & Hirn.
316. *tiffanii* Ackley, Mss.
317. *trioicum* Woronichkin.
318. *tumidulum* (Kuetz.) Wittr.
319. *tyrolicum* Wittr.
320. *uleanum* Hirn.
321. *undulatum* (Breb.) Al. Br.; Wittr.
322. " var. *americanum* Transeau.
323. *undulatum* f. *senegalense* (Nordst). Hirn.
324. *upsaliense* Wittr.
325. " var. *fennicum* Hirn.
326. *urbicum* Wittr.
327. *urceolatum* Nordst. & Hirn.
328. *varians* Wittr. & Lund.
329. *vaucherii* (Le Cl.) Al. Br.; Wittr.
330. *velatum* Hallas.
331. *verrucosum* Hallas.
332. *vesicatum* (Lyngbye) Wittr.
333. *victoriense* G. S. West.
334. *virceburgense* Hirn.
335. *wabashense* Tiffany.
336. *warmingianum* Wittr.
337. *welwitschii* West.
338. *wolleanum* Wittr.
339. " f. *insigne* (Nordst.) Hirn.
340. " var. *concinnum* Hirn.
341. *wyliei* Tiffany.
342. *zigzag* Cleve.
343. " var. *robustum* West.
344. *pyrulum* var. *amplius* W.R.Taylor.

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ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1928.*

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By the continued activity of the botanists of the state many rare specimens have been added to the state herbarium. The more important are listed below with the names of the donors. The writer, as in the past, takes the responsibility for the determinations. In the past year R. G. Adams and Co., of Columbus, Ohio, have published the writer's "Field Manual of the Flora of Ohio and Adjacent Territory." This Manual can be used as a check list as well as for identification and taxonomy until a new catalog of Ohio plants is published. It is hoped that the forthcoming Botanical Congress, to be held in Cambridge, England, will establish a better system of rules of nomenclature and that a new Catalog of Ohio Vascular Plants, brought up to date, can then be published.

4. *Botrychium lanceolatum* (Gmel.) Angs. Lanceleaf Grape-fern Gustavus Twp., Trumbull Co. Lawrence E. Hicks.

25. *Asplenium ruta-muraria* L. Wall-rue Spleenwort. Change name to *Asplenium cryptolepis* Fern. American Wall-rue Spleenwort. Distribution—Highland Co., two localities, Adams Co. The specimen from Adams Co. collected by Mrs. Bayard Taylor, is somewhat intermediate between the species and the variety given below. Add also to record, Cedar Falls, Jefferson Twp., Adams Co. Apparently typical specimens of the species collected in 1928 by R. B. Gordon, Conrad Roth, and E. Lucy Braun.

25a. *Asplenium cryptolepis ohionis* Fern. Ohio Wall-rue Spleenwort. In Clifton Gorge, Clifton, Greene Co. Specimens in the herbarium collected at various intervals, the first in 1873 by Hannah Jane Biddlecombe. Several years ago Miss Biddlecombe called my attention to the peculiar plant from Clifton Gorge and said that she thought it was a new variety or new species. Years ago she had expressed this opinion to a prominent eastern systematic botanist, but he never took up the matter. I was preparing to describe it and to name it for its discoverer, Miss Biddlecombe, having already made sketches and partial descriptions. In the meantime Fernald has finally

* Papers from the Department of Botany, The Ohio State University No. 234.

given it a name. The juvenile form is practically indistinguishable from the species, but the mature leaves are strikingly different.

53. *Equisetum laevigatum* A. Br. Smooth Scouring-rush. West of Holland, Lucas Co. E. L. Moseley.

53.1. *Equisetum kansanum* Schaffn. Kansas Scouring-rush. Along interurban railway track and in prairie below. East of Harmony, Clark Co. John H. Schaffner.

54. *Equisetum fluviatile* L. Water Horsetail. Neapolis, Lucas Co. E. L. Moseley.

58. *Lycopodium lucidulum* Mx. Shining Club-moss. Swanton, Fulton Co. E. L. Moseley.

60. *Lycopodium inundatum* L. Bog Club-moss. "Sand pit," Holland, Lucas Co. E. L. Moseley and Edgar Hovey.

61. *Lycopodium clavatum* L. Common Club-moss. Northern Trumbull Co. Lawrence E. Hicks.

63. *Lycopodium complanatum* L. Trailing Club-moss. North part of Trumbull Co. Lawrence E. Hicks. Chillicothe, Ross Co. M. G. Dickey.

75. *Juniperus virginiana* L. Red Juniper. Staminate tree blown over, but still with root connection on one side. Covered with staminate cones and here and there a normal carpellate cone (sex-reversal). On Alum creek, about seven miles east of Delaware, Delaware Co. Glenn W. Blaydes.

139.1. *Cyperus ovularis* (Mx.) Torr. Globose Cyperus. Higby Prairie, Ross Co. Floyd Bartley and E. S. Thomas.

146. *Kyllinga pumila* Mx. Low Kyllinga. Monclova, Lucas Co. E. L. Moseley.

159. *Fimbristylis autumnalis* (L.) R. & S. Slender Fimbristylis. Hillsboro, Highland Co. Katie M. Roads.

159.1. *Hemicarpha micrantha* (Vahl.) Pax. Common Hemicarpha. "In a ditch on east and west road west of Monclova," Lucas Co. E. L. Moseley.

176. *Rynchospora glomerata* (L.) Vahl. Clustered Beak-rush. Holland, Lucas Co. E. L. Moseley.

184.1. *Carex texensis* (Torr.) Bail. Texas Sedge. On lawn, forming a turf, Columbus, Franklin Co. Apparently introduced from the south. "When established, forms nearly pure stands." A. E. Waller.

202. *Carex canescens* L. Silvery Sedge. Ten miles south of Monroeville, Huron Co. E. L. Moseley.

216.2. *Carex suberecta* (Olney) Britt. Prairie Straw Sedge. "In a swamp," Hillsboro, Highland Co. Katie M. Roads.

231. *Carex aurea* Nutt. Golden-fruited Sedge. "Along a ditch five miles north of Monclova," Lucas Co. Specimens also from "Blue Hole," Castalia, Erie Co. E. L. Moseley.

236. *Carex platyphylla* Car. Broad-leaf Sedge. Spring Valley, near Granville, Licking Co. A. E. Waller.

245. *Carex crawei* Dew. Crawe's Sedge. Bowling Green, Wood Co. E. L. Moseley.

248. *Carex conoidea* Schk. Field Sedge. Vermilion R., Florence Twp., Erie Co. E. L. Moseley.

252. *Carex gracillima* Schw. Graceful Sedge. "In swamp woods," Union Twp., Highland Co. Katie M. Roads.

292. *Carex intumescens* Rudge. Bladder Sedge. "In a swamp." Union Twp., Highland Co. Katie M. Roads.

295.1. *Arundinaria tecta* (Walt.) Muhl. Small Cane. A large patch growing spontaneously in a swamp near Otterbein Home, about four miles from Lebanon, Warren Co. "Stems 1.5–4.5 m. high and .5—1+ cm. in diameter. Tips winter-killed." F. A. McClure.

302. *Bromus inermis* Leyss. Hungarian Brome-grass. "Collected along the railroad track." Hillsboro, Highland Co. Katie M. Roads.

303. *Bromus ciliatus* L. Fringed Brome-grass. Whitehouse, Lucas Co. E. L. Moseley.

330. *Poa alsodes* Gr. Grove Meadow-grass. "In woods," near Hillsboro, Highland Co. Katie M. Roads.

334. *Eragrostis pectinacea* (Mx.) Steud. Purple Love-grass. Zanesville, Muskingum Co. C. A. Butler. Buchtel, Athens Co. Len. Stephenson.

349. *Phragmites phragmites* (L.) Karst. Common Reed-grass. Along Pymatuning R., Northern Trumbull Co. Lawrence E. Hicks.

359. *Nothoholcus lanatus* (L.) Nash. Velvet-grass. Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

372a. *Hordeum vulgare trifurcatum* Schlecht. Hooded Barley. Penn Twp., Highland Co. Katie M. Roads.

375. *Hordeum jubatum* L. Squirrel-tail Barley. "In a pasture lot." Hillsboro, Highland Co. Katie M. Roads.

383. *Sporobolus asper* (Mx.) Kunth. Longleaf Rush-grass. Pike Twp., Madison Co. E. N. Transeau and E. S. Thomas.

391.1. *Agrostis perennans* (Walt.) Tuck. Upland Bent-grass. New Vienna, Clinton Co. Katie M. Roads.

396. *Alopecurus geniculatus* L. Marsh Foxtail. "Along roadside ditch." Fredericktown, Knox Co. Lawrence E. Hicks.

410. *Aristida dichotoma* Mx. Poverty-grass. Hocking Co. E. S. Thomas, A. E. Harper and E. L. Moseley.

414. *Torresia odorata* (L.) Hitchc. Vanilla-grass. "In a swampy place in a small wood." Union Twp., Highland Co. Katie M. Roads.

417. *Anthoxanthum odoratum* L. Sweet Vernal-grass. "Damp woodland clearing near Pymatuning R." Northern Trumbull Co. Lawrence E. Hicks.

419. *Panicum agrostoides* Spreng. Agrostis-like Panic-grass. Northern Trumbull Co. Andover, Ashtabula Co. Lawrence E. Hicks.

423. *Panicum miliaceum* L. Millet Panic-grass. "Along the railroad." Hillsboro, Highland Co. Katie M. Roads.

426. *Panicum flexile* (Gatt.) Scrib. Wiry Panic-grass. Marshall Twp., Highland Co. Katie M. Roads.

428. *Panicum depauperatum* Muhl. Starved Panic-grass. Midway, Lucas Co. E. L. Moseley.

433. *Panicum polyanthes* Schultes. Many-flowered Panic-grass. Hocking Co. E. S. Thomas and E. L. Moseley.

436. *Panicum boreale* Nash. Northern Panic-grass. Midway, Lucas Co. E. L. Moseley.

441. *Panicum tsugetorum* Nash. Hemlock Panic-grass. Swanton, Fulton Co. E. L. Moseley.

443. *Panicum scribnerianum* Nash. Scribner's Panic-grass. Midway, Lucas Co. E. L. Moseley.

448a. *Panicum boscii molle* (Vas.) Hitch. and Ch. "Upland hydrophytic forest," North College Hill, Hamilton Co. E. Lucy Braun.

456.1. *Paspalum circulare* Nash. Round-flowered Paspalum. "Very abundant in a pasture lot in a low place." Hillsboro, Highland Co. Katie M. Roads. Also prairie near Higby, Ross Co. Floyd Bartley and E. S. Thomas. Buchtel, Athens Co. Len. Stephenson.

468. *Miscanthus sinensis* Anderss. Chinese Plume-grass. "Escaped one mile north of Orwell," Ashtabula Co. Lawrence E. Hicks.

469.1. *Andropogon elliotii* Chapm. Elliott's Beard-grass. Buchtel, Athens Co. Len Stephenson. Section 23, Hocking Twp., Fairfield Co. "Along with *A. virginicus* L." E. S. Thomas and L. E. Hicks.

499. *Chamaelirium luteum* (L.) Gr. Chamaelirium. Savageville School, Jackson Co. "On a west slope." Lois Lampe.

504. *Trillium declinatum* (Gr.) Gleason. Drooping Trillium. White flowered variety. Fredericktown, Knox Co. Lawrence E. Hicks.

511.1. *Disporum maculatum* (Buckl.) Britt. Spotted Disporum. With dark purple spots on the perianth segments and long anther filaments. A mere fragment, but undoubtedly this species. Near Waverly, Pike Co. Beryl Finney.

545. *Juncus torreyi* Cov. Torrey's Rush. Licking Narrows, Licking Co. R. B. Gordon. Along Pymatuning R., Northern Trumbull Co. Williamsfield Twp., Ashtabula Co. Lawrence E. Hicks.

549. *Juncus canadensis* J. Gay. Canada Rush. Spencer Twp., Lucas Co. E. L. Moseley.

556.1. *Narcissus poeticus* L. Poet's Narcissus. Native of Europe. "In a field." Hillsboro, Highland Co. Also in Marshall Twp., along road (double flowered variety). Katie M. Roads.

556.2. *Narcissus pseudo-narcissus* L. Daffodil. Native of Europe. "Propagates itself readily in neglected yards and near-by waste places." Hillsboro, Highland Co. Katie M. Roads.

557.3. *Iris foliosa* Mack. and Bush. Leafy Blue-flag. "Escaped to a small bank in a vacant lot." Hillsboro, Highland Co. Katie M. Roads.

571. *Gymnadeniopsis clavellata* (Mx.) Rydb. Green Wood-orchis. Wayne Twp., Ashtabula Co. "Also in Trumbull and Geauga Cos." Lawrence E. Hicks.

572. *Limnorchis hyperborea* (L.) Rydb. Tall Bog-orchis. "In a sphagnum bog," Richland Twp., Huron Co. Charles F. Walker.

573. *Lysias orbiculata* (Pursh) Rydb. Large Roundleaf Orchis. "In woods, north bank of Clear Fork Gorge." Ashland Co. Charles F. Walker.

575. *Blephariglottis ciliaris* (L.) Rydb. Yellow Fringed-orchis. "Seventy plants along roadside on one side of road within 100 yards." Swanton Twp., Lucas Co. E. L. Moseley.

577. *Blephariglottis lacera* (Mx.) Farw. Ragged Fringed-orchis. Wayne Twp., Ashtabula Co. Northern Trumbull Co. Lawrence E. Hicks.

583. *Triphora trianthophora* (Sw.) Rydb. Nodding Triphora. "Rare in damp, dense woods." Williamsfield Twp., Ashtabula Co. "Also seen in southern Wayne Twp." Lawrence E. Hicks.

586. *Ibidium strictum* (Rydb.) House. Hooded Lady's-tresses. Northern Trumbull Co. Burton, Geauga Co. Lawrence E. Hicks.

588. *Ibidium cernuum* (L.) House. Nodding Lady's-tresses. Dean Forest, Lawrence Co. Charles F. Walker.

594. *Malaxis unifolia* Mx. Green Addermouth. Ten miles northwest of Ironton, Lawrence Co. H. C. Sampson.

602. *Corallorrhiza odontorhiza* (Willd.) Nutt. Small-flowered Coral root. "On tops of ridges." Laurelville, Hocking Co. W. H. Camp.

627. *Coptis trifolia* (L.) Salisb. Gold-thread. "Damp woods." Near Wayne, Ashtabula Co. Also North Trumbull Co. Lawrence E. Hicks. Kingsville, Ashtabula Co. Geo. Sleesman.

657.1. *Berberis thunbergii* DC. Japanese Barberry. "Escaped in three localities; some bushes 3 ft. high." Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

700. *Lepidium draba* L. Hoary Peppergrass. "Along the road near Athens," Athens Co. P. S. Wamsley.

706. *Sophia pinnata* (Walt.) Howell. Pinnate Tansy-mustard. Hillsboro, Highland Co. Katie M. Roads.

707. *Sophia incisa* (Engelm.) Green. Western Tanzy-mustard. "In a freight-yard." Hillsboro, Highland Co. Katie M. Roads.

708. *Cheirinia cheiranthoides* (L.) Link. Worm-seed Mustard. "Wet woods near edge of Scioto Marsh." McGuffey, Hardin Co. R. A. Dobbins. "In the freight yards," Hillsboro, Highland Co. Katie M. Roads.

718. *Barbarea stricta* Andrz. Erect Winter-cress. "On river bank." Wapakoneta, Auglaize Co. Wm. Kayser.

715. *Hesperis matronalis* L. Dame's Rocket. Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

755. *Cleome spinosa* L. Spider-flower. Andover, Ashtabula Co. Lawrence E. Hicks.

761. *Geranium molle* L. Dove's-foot Crane's-bill. "In a lawn." Wapakoneta, Auglaize Co. Wm. Kayser.

762. *Geranium pusillum* L. Small-flowered Crane's-bill. Bowling Green, Wood Co. E. L. Moseley.

776. *Linum medium* (Planch.) Britt. Stiff Flax. Higby Prairie, Ross Co. Floyd Bartley and E. S. Thomas.

783. *Polygala cruciata* L. Crossleaf Milkwort. North of Glengary, Lucas Co. E. L. Moseley.

788. *Polygala polygama* Walt. Racemed Milkwort. With white flowers. Near Wabash R. R., South of Swanton, Fulton Co. Mrs. Ralph Engle.

817. *Malva sylvestris* L. High Mallow. "In a vacant lot." Hillsboro, Highland Co. Katie M. Roads. Wapakoneta, Auglaize Co. W. M. Kayser.

827. *Napaea dioica* L. Glade-mallow. Jackson road at Scioto R., Ross Co. Floyd Bartley and E. S. Thomas.

840. *Hypericum cistifolium* Lam. Round-podded St. John's-wort. Dunn's prairie, Madison Co. Edward S. Thomas.

849. *Sarothra gentianoides* L. Orange-grass. Bogart, Erie Co. Geo. Sleesman.

850. *Triadenum virginicum* (L.) Raf. Marsh St. John's-wort. Three miles east of Kingston, Ross Co. Floyd Bartley and Edward S. Thomas.

852. *Crocanthemum majus* (L.) Britt. Hoary Frostweed. North of Whitehouse, Lucas Co. E. L. Moseley.

854. *Lechia minor* L. Thyme-leaf Pinweed. Spencer Twp., Lucas Co. E. L. Moseley.

873. *Viola pallens* (Banks) Brain. Woodland White Violet. In bog near Celeryville, Huron Co. Hiram Thut and R. B. Gordon.

875.1. *Viola cucullata* Art. Marsh Blue Violet. Three miles east of Kingston, Ross Co. Floyd Bartley and E. S. Thomas.

884. *Viola sagittata* Ait. Arrowleaf Violet. Prairie near Higby, Ross Co. Floyd Bartley and E. S. Thomas. Wayne Twp., Ashtabula Co. Lawrence E. Hicks. Beverly, Washington Co. Mrs. Elizabeth T. Owen.

898. *Alsine graminea* (L.) Britt. Lesser Stitchwort. "Along a steep bank." Hillsboro, Highland Co. Katie M. Roads.

912. *Silene latifolia* (Mill.) Britt & Rend. Bladder Campion. "In old field above Clear Fort Gorge," Ashland Co. Charles F. Walker and Lawrence E. Hicks.

916. *Silene noctiflora* L. Night-blooming Catchfly. "Fairly common weed in fields." Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

925. *Dianthus armeria* L. Deptford Pink. Williamsfield Twp., Ashtabula Co. Also near Pymatuning R., North Trumbull Co. Lawrence E. Hicks.

927. *Dianthus barbatus* L. Sweet-William. "Occasional escape." Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

933. *Allionia nyctaginea* Mx. Heartleaf Umbrella-wort. Buchtel, Athens Co. Len. Stephenson.

951. *Chenopodium glaucum* L. Oakleaf Goosefoot. Hillsboro, Highland Co. Katie M. Roads.

955. *Chenopodium boscianum* Moq. Bosc's Goosefoot. Barnesville, Belmont Co. Emma E. Laughlin. Hillsboro, Highland Co. Katie M. Roads.

1009. *Potentilla recta* L. Upright Cinquefoil. Western Preble Co. Katie M. Roads.

1022.1. *Rubus laciniatus* Willd. Cutleaf Blackberry. In waste ground, Clinton Twp., Franklin Co. John H. Schaffner. Also South Bass Island, Ottawa Co. "Escaped and established in several places." M. E. Stickney.

1034. *Filipendula rubra* (Hill.) Rob. Queen-of-the-prairie. Colebrook, Ashtabula Co. J. S. Hine and C. F. Walker.

1037. *Spiraea tomentosa* L. Steeple-bush. Higby Prairie, Ross Co. Floyd Bartley and E. S. Thomas.

1039. *Dalibarda repens* L. Dalibarda, near Chardon, Geauga Co. Lawrence E. Hicks.

1053. *Sorbus scopulina* Greene. Western Mountain-ash. Northern Trumbull Co. Barton, Geauga Co. Lawrence E. Hicks.

1086. *Prunus mahaleb* L. Mahaleb Cherry. Near Hillsboro, Highland Co. John D. Roads.

1104. *Baptisia leucantha* T. & G. Large White Wild-indigo. Dunn's prairie, Madison Co. Edward S. Thomas.

1126. *Psoralea onobrychis* Nutt. Sainfoin Psoralea. West of Adelphi, Ross Co. Floyd Bartley and Edward S. Thomas. Buchtel, Athens Co. Len. Stephenson.

1148. *Meibomia rigida* (Ell.) Ktz. Rigid Tick-trefoil. North-west of Monclova, Lucas Co. E. L. Moseley.

1150. *Meibomia obtusa* (Muhl.) Vail. Ciliate Tick-trefoil. Hocking Co. E. S. Thomas and E. L. Moseley.

1153. *Lespedeza nuttallii* Darl. Nuttall's Bush-clover. Fairfield Co. E. S. Thomas and E. L. Moseley.

1154. *Lespedeza violacea* (L.) Pers. Violet Bush-clover. Stanhope Gorge, Williamsfield Twp., Ashtabula Co. Lawrence E. Hicks.

1157. *Lespedeza virginica* (L.) Britt. Slender Bush-clover. Hocking Co. E. L. Moseley, A. R. Harper and E. S. Thomas.

1160. *Lespedeza capitata* Mx. Round-headed Bush-clover. Higby Prairie, Ross Co. Floyd Bartley and E. S. Thomas.

1160.1. *Lespedeza striata* (Thunb.) H. & A. Japan Clover. Jackson Road at Scioto River, Ross Co. Floyd Bartley and E. S. Thomas.

1172. *Lathyrus ochroleucus* Hook. Cream-colored Pea. "In tamarack bog near Portage Lakes," Summit Co. Charles F. Walker.

1182. *Sedum telephioides* Mx. American Orpine. Escaped near Andover, Ashtabula Co. Lawrence E. Hicks.

1195. *Rotala ramosior* (L.) Koehne. Rotala. "In shallow ditch east of Cook School, west of Toledo," Lucas Co. E. L. Moseley.

1200. *Rhexia virginica* L. Virginia Meadow-beauty. Higby Prairie, Ross Co. Floyd Bartley and E. S. Thomas. Bogart, Erie Co. Geo. Sleesman.

1205. *Rhamnus alnifolia* L'Her. Alderleaf Buckthorn. "Tamarack bog near Portage Lakes," Summit Co. Charles F. Walker.

1241. *Cotinus cotinus* (L.) Sarg. European Smoke-tree. "A common escape." Near Wick, Wayne Twp., Ashtabula Co. Also Northern Trumbull Co. Lawrence E. Hicks.

1253. *Humulus japonicus* S. & Z. Japanese Hop. "Escaped near Andover," Ashtabula Co. Lawrence E. Hicks.

1281. *Betula lenta* L. Sweet Birch. Wayne Twp., Ashtabula Co. Burton, Geauga Co. Lawrence E. Hicks.

1298. *Populus heterophylla* L. Swamp Poplar. Williamsfield Twp., Ashtabula Co., Northern Trumbull Co. Lawrence E. Hicks.

1322. *Salix pedicellaris* Pursh. Bog Willow. New Haven Bog, Richmond Twp., Huron Co. Robert B. Gordon.

1324.1. *Philadelphus inodorus* L. Scentless Mock-orange. "In a pasture lot along the railroad tracks." Liberty Twp., Highland Co. Probably escaped from cultivation. Katie M. Roads.

1338. *Epilobium lineare* Muhl. Linear-leaf Willow-herb. "Prairie." Spencer Twp., Lucas Co. E. L. Moseley.

1362. *Cucumis melo* L. Muskmelon. "In a neglected pasture lot." Hillsboro, Highland Co. Katie M. Roads.

1379. *Trientalis americana* (Pers.) Pursh. Star-flower. "Dry woods." North Trumbull Co. Lawrence E. Hicks. Kingsville, Ashtabula Co. Geo. Sleesman.

1388. *Chimaphila umbellata* (L.) Nutt. Pipsissewa. Sugar Grove, Fairfield Co. B. S. Meyer.

1392. *Hypopitys lanuginosa* (Mx.) Nutt. Hairy Pinesap. Rock Hill, Ross Co. Floyd Bartley. "On south and west facing slopes." Laurelville, Hocking Co. W. H. Camp.

1402. *Epigaea repens* L. Trailing Arbutus. Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

1424.1. *Navarretia intertexta* (Benth.) Hook. Navarretia. Blue-flowered variety. "Several small patches in a large pasture, growing for a number of years." Introduced from the west. Lafayette, Allen Co. Alfred Hedges and R. A. Dobbins.

1428. *Ipomoea lacunosa* L. Small-flowered White Morning-glory. Hillsboro, Highland Co. Also in Liberty Twp., Highland Co. Katie M. Roads.

1432. *Convolvulus spithamaeus* L. Upright Bindweed. East of Gahanna, Franklin Co. John H. Schaffner.

1441. *Cuscuta cephalanthi* Engelm. Buttonbush Dodder. Glengary, Lucas Co. E. L. Moseley.

1466. *Gentiana puberula* Mx. Downy Gentian. Cook School, "Oak openings," west of Toledo, Lucas Co. E. L. Moseley.

1467. *Gentiana saponaria* L. Soapwort Gentian. Prairie near Higby, Ross Co. Floyd Bartley and E. S. Thomas.

1472. *Obolaria virginica* L. Pennywort. Beverly, Washington Co. Mrs. Elizabeth T. Owen.

1473. *Bartonia virginica* (L.) B. S. P. Yellow Bartonia. "Rare plant along Pymatuning R. in short grass pasture." Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

1481. *Acerates floridana* (Lam.) Hitchc. Florida Milkweed. One mile north of Carpenter, Meigs Co. H. C. Sampson.

1494. *Gonolobus laevis* Mx. Sandvine. "In a thicket along railroad embankment on west bank of Scioto River, south of Greenlawn Ave., Columbus, Franklin Co. Robert B. Gordon.

1515. *Solanum rostratum* Dun. Buffalo-bur. Hillsboro, Highland Co. Katie M. Roads.

1521.1. *Chelone obliqua* L. Red Turtle-head. Near Black Fork, Washington Twp., Lawrence Co. Charles F. Walker. Also Hocking Co. E. S. Thomas and E. L. Moseley. In a swamp, Wapakoneta, Auglaize Co. W. M. Kayser.

1553. *Aureolaria virginica* (L.) Penn. (Dasystoma flava (L.) Wood). Downy False Floxglove. Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

1554. *Aureolaria laevigata* (Raf.) Raf. Entire-leaf False Foxglove. Rock Hill, Ross Co. Floyd Bartley.

1561. *Castilleja coccinea* (L.) Spreng. Scarlet Painted-cup. Green Brier District, Jefferson Twp., Adams Co. R. B. Gordon, Conrad Roth and E. Lucy Braun.

1568. *Chaenorrhinum minus* (L.) Lange. Lesser Toadflax. Wapakoneta, Auglaize Co. Along railroad track. Wm. Kayser. Ada, Hardin Co. R. A. Dobbins.

1607. *Echium vulgare* L. Blueweed. "In the freight yard." Hillsboro, Highland Co. Katie M. Roads.

1616. *Trichostema dichotomum* L. Blue-curls. Clear Creek, Hocking Co. A. R. Harper and E. L. Moseley.

1627. *Scutellaria integrifolia* L. Hyssop Skullcap. Higby Prairie, Ross Co. Floyd Bartley and E. S. Thomas.

1646. *Cunila origanoides* (L.) Britt. American Dittany. Perry Co. E. A. Albaugh.

1666.1. *Dracocephalum speciosum* Sw. Showy Dragonhead. Along the Scioto river, five miles southwest of Marion, Marion Co. Native of the Mississippi valley. Differs from *D. virginianum* L. by having the upper leaves not conspicuously reduced; by its having a very robust stem and thick, somewhat fleshy leaves; and by its acute, triangular calyx-teeth. E. N. Transeau and H. C. Sampson.

1668.1. *Galeopsis ladanum* L. Red Hemp-nettle. Broad-leaved variety. "A very large patch along the railroad track." Hillsboro, Highland Co. Katie M. Roads.

1672. *Lamium purpureum* L. Red Henbit. Hillsboro, Highland Co. Katie M. Roads.

1687. *Salvia lanceifolia* Poir. Lanceleaf Sage. "Edge of field of soybeans." Wapakoneta, Auglaize Co. W. M. Kayser.

1691. *Plantago cordata* Lam. Heartleaf Plantain. "Edge of swamp east of Indian Lake." Richland Twp., Logan Co. James S. Hine.

1695.1. *Plantago purshii* R. & S. Purshe's Plantain. "Plentiful in a pasture near Wabash R. R. south of Swanton," Fulton Co. Sent in along with *P. aristata*. Mrs. Ralph Engle and E. L. Moseley.

1739. *Carum carui* L. Caraway. Wapakoneta, Auglaize Co. "Along road." Wm. Kayser.

1744. *Cornus stolonifera* Mx. Red-osier Dogwood. Three miles east of Kingston, Ross Co. Floyd Bartley and E. S. Thomas.

1777. *Viburnum dentatum* L. Toothed Arrow-wood. Remove distribution record, Martinsville, Clinton Co. (1926) from the list. The plant is evidently *V. scabrellum*.

1778. *Viburnum scabrellum* (T. & G.) Chapm. Roughleaf Arrow-wood. "A few shrubs on Rabbit Island," Buckeye Lake, Perry Co. Charles F. Walker. Also in prairie near Higby, Ross Co. E. S. Thomas.

1784. *Viburnum opulus americanum* (Mill.) Art. Cranberry-tree. "Open swampy places, fairly common." Williamsfield Twp., Ashtabula Co. Lawrence E. Hicks.

1785. *Viburnum alnifolium* Marsh. Hobblebush. Along Pymatuning R., Northern Trumbull Co. Lawrence E. Hicks.

1802. *Diervilla diervilla* (L.) MacM. Bush-honeysuckle. Clear Fork Gorge, Southern Ashland Co. Conneaut R., Ashtabula Co. Lawrence E. Hicks.

1817. *Lobelia puberula* Mx. Downy Lobelia. "Roadside," Washington Twp., Lawrence Co. Charles F. Walker. Also prairie near Higby, Ross Co. Floyd Bartley and E. S. Thomas.

1844. *Helianthus grosse-serratus* Mart. Sawtooth Sunflower. Lafayette, Allen Co. Alfred Hedges.

1856. *Helianthus petiolaris* Nutt. Prairie Sunflower. "In the freight yard," Hillsboro, Highland Co. Katie M. Roads.

1861. *Coreopsis major* Walt. Greater Tickseed. Ten miles west of Ironton, Lawrence Co. H. C. Sampson.

1864. *Bidens laevis* (L.) B. S. P. Smooth Bur-marigold. Buchtel, Athens Co. Len. Stephenson.

1867. *Bidens comosa* (Gr.) Wieg. Leafy-bracted Bur-marigold. Little Darby Creek, near Irwin, Union Co. E. N. Transeau and E. S. Thomas.

1874.1. *Cosmos bipinnatus* Cav. Cosmos. "Escaped in several places near Wick," Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

1886. *Helenium nudiflorum* Nutt. Purple-headed Sneezeweed. Hocking Co. Arthur R. Harper, E. S. Thomas and E. L. Moseley.

1895. *Anaphalis margaritacea* (L.) Benth. & Hook. Pearly Everlasting. Northern Trumbull Co. Near Burton, Geauga Co. Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

1901. *Grindelia squarrosa* (Pursh) Dun. Broadleaf Gum-plant. Lafayette, Allen Co. Alfred Hedges.

1908. *Solidago hispida* Muhl. Hairy Goldenrod. Northeast of Cook School, "Oak openings," west of Toledo, Lucas Co. E. L. Moseley.

1928. *Boltonia asteroides* (L.) L'Her. Boltonia. Ada, Hardin Co. R. A. Dobbins.

1938. *Aster drummondii* Lindl. Drummond's Aster. Madison Co. "Also at Boulder Dam, Scioto R.," Delaware Co. Edward S. Thomas.

1940. *Aster undulatus* L. Wavy-leaf Aster. Hocking Co. Also in Red Hills, Franklin Co., Rock Hill, Ross Co., and Fairfield Co. "Abundant on dry, sunny hillsides." E. S. Thomas and E. L. Moseley.

1941. *Aster patens* Ait. Late Purple Aster. Perry Co. E. A. Albaugh.

1942. *Aster phlogifolius* Muhl. Haines, Hocking Co. Floyd Bartley and E. S. Thomas.

1951. *Aster vimineus* Lam. Small White Aster. Liberty Twp., Highland Co. Katie M. Roads.

1954. *Aster salicifolius* Lam. Willow Aster. Holland, Lucas Co. E. L. Moseley.

1966. *Doellingeria umbellata* (Mill.) Nees. Tall White-top Aster. Cedar Swamp, Champaign Co. John H. Schaffner, Robert B. Gordon and W. H. Camp.

1971. *Eupatorium altissimum* L. Tall Thoroughwort. Kibler's prairie, Pickaway Co. Floyd Bartley and Edward S. Thomas.

1973. *Eupatorium rotundifolium* L. Roundleaf Thoroughwort. "Neotoma," Hocking Co. E. L. Moseley.

1976. *Eupatorium aromaticum* L. Smaller White Snake-root. Revenge, Fairfield Co. E. S. Thomas and E. L. Moseley.

1982. *Lacinaria scariosa* (L.) Hill. Large Blazing-star. Perry Co. E. A. Albaugh.

1991. *Anthemis arvensis* L. Field Dog-fennel. Wapakoneta, Auglaize Co. "Along railroad track." Wm. Kayser.

2011. *Synosma suaveolens* (L.) Raf. Sweet-scented Indian-plantain. Canal Winchester, Franklin Co. E. S. Thomas.

2015. *Senecio vulgaris* L. Common Groundsel. "Common in the waste places of the Ernst's Nursery Gardens." Eaton, Preble Co. Katie M. Roads.

2026a. *Cirsium arvense integrifolium* Wimm & Grab. Bellefontaine, Logan Co. Myron Headington and E. L. Moseley.

2026.1. *Mariana mariana* (L.) Hill. Mary's Thistle. "Accidental in a garden." Bowling Green, Wood Co. E. L. Moseley.

2029.2. *Centaurea nigra* L. Black Star-thistle. Salt Creek Twp., Pickaway Co. Floyd Bartley.

2030.1. *Centaurea solstitialis* L. Barnaby's Star-thistle. Webster Twp., Wood Co. E. L. Moseley.

2056. *Hieracium paniculatum* L. Panicled Hawkweed. Hocking Co. E. L. Moseley, A. R. Harper and E. S. Thomas. Also Rock Hill, Ross Co. Floyd Bartley.

2063. *Hieracium aurantiacum* L. Orange Hawkweed. Madison, Lake Co. Geo. Sleesman.

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THE ORIGIN OF THE PHARYNGEAL TEETH OF THE CARP.

(CYPRINUS CARPIO LINNÆUS)*.

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INTRODUCTION.

The doctrine of the specificity of the germ layers postulates, among other things, that the enamel-organs of the teeth of vertebrates be derived from ectodermal epithelium. The presence of teeth in the oral cavity of vertebrates is accounted for by the invagination of the integument during the formation of the stomodæum. This process would result in the carrying inward of the ectoderm and any of its derivatives such as placoid scales—structures which are said to be homologous with the teeth of vertebrates. Since the dermal denticles or placoid scales of elasmobranchs are comparable as to structure and method of development with their teeth, the latter are usually considered nothing more than highly developed spines of the skin, and, since the teeth of elasmobranchs are morphologically similar to those of other vertebrates, it is inferred that all teeth bear a similar relation to the integument. Furthermore, according to the above mentioned doctrine, the epithelial lining of the digestive tract including the pharynx is derived from endoderm. Therefore, the fact that placoid scales are present in the pharyngeal cavity of certain elasmobranchs and the fact that pharyngeal teeth occur in many teleosts raises questions as to the validity of this doctrine and at the same time casts doubt on the origin of such structures.

*Dissertation presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of the Ohio State University.

The difficulties of determining the boundaries of ectoderm and endoderm in the oro-pharyngeal cavity of fishes after the formation of the oral and pharyngeal clefts constitutes a considerable obstacle in attempting to solve the problem of the origin of these supposed ectodermal derivatives in this endodermal territory. Nevertheless, extensive investigation has been carried out and various theories have been proposed to account for the presence of these structures in this region. The adherents of the doctrine of the specificity of the germ layers maintain that the presence of teeth in any region is an accurate criterion for the existence of ectoderm in that region at some time in development. They assume, therefore, that these structures are derived from ectoderm which has migrated into this region. They hold, furthermore, that it may be determined how far the ectoderm invaginates into the mouth and pharyngeal cavity of fishes by determining the distribution of placoid scales and teeth in such regions. Two suggestions have been offered as to the probable course of this ectodermal migration: first, that after the rupture of the oral plate the invaginated ectoderm continues to grow posteriorly into the pharynx; second, that the lateral invaginations of the ectoderm, which fuse with similar evaginations of the endoderm to form the pharyngeal clefts, grow inward to the pharyngeal cavity. Thus, according to this idea, the dermal denticles in the pharynx of elasmobranchs and the pharyngeal teeth of teleosts are formed in a manner comparable with that of those in the oral cavity.

O. Hertwig ('74) and Gegenbaur ('98) were among the first to advance the theory of ectodermal migration in order to account for the presence of these structures in the pharynx of fishes. According to these authors ectoderm must grow into the pharynx in the case of fishes if placoid scales and teeth are to be considered as derived from it, since endoderm does not possess the capacity to form teeth.

Steinhard ('03) examined the oral and pharyngeal cavities of numerous species of elasmobranchs with the view to determining the form, arrangement and distribution of placoid scales in these regions. He found that in most of the species examined the whole of the oral and pharyngeal cavities, together with the branchial arches, are almost completely covered with these scales and that they often extend as far back as the commencement of the œsophagus. He mentioned that it is difficult

to account for the presence of such structures over an area like the pharynx which is of supposed endodermal origin. He was of the opinion, however, that, although there is a possibility of the endoderm having acquired a capacity to form dermal denticles, their presence in that region is more likely due to a migration of ectoderm.

Imms ('04) studied the structure of the gill-rakers of the Spoonbill Sturgeon (*Polyodon spatula*) and found that there is a striking similarity between them and the teeth of vertebrates. He offered the suggestion (page 29) "that possibly the gill-rakers of *Polyodon* are morphologically the much modified descendants of exoskeletal structures which have migrated along with the ectoderm on to the branchial arches. The fact that the mucous membrane covering the branchial arches is regarded as being endodermal in origin, offers considerable difficulty to any idea that such structures could have developed there independently and in situ . . . . It is worthy of note that, with regard to the pharyngeal teeth of many fishes, several writers are inclined to believe that their presence is due to a migration of the ectoderm into the cavity of the pharynx. For this reason, and on account of the difficulty of reconciling them with the presence of anything except ectoderm, I would suggest the possibility that the skeletal tissue of the gill-rakers of *Polyodon* has arisen from portions of the gill-clefts, which have migrated on to the inner or pharyngeal margins of the branchial arches. At all events, if any migration of epiblast has taken place, the latter route seems as feasible as a backward migration from the stomodæum."

Following up the suggestion that the gill-rakers of *Polyodon* may perhaps be regarded as modified dermal denticles, Imms ('05) carried out an investigation with the view to determining the distribution of dermal denticles in the pharyngeal cavity of a considerable number of species of elasmobranchs. His results were practically identical with those of Steinhard ('03). He discovered and emphasized the fact that variations occur in the distribution of the denticles in the oro-pharyngeal cavity of these forms. He described the predominating method of distribution as occurring in those species where the denticles are uniformly distributed over the entire mucous membrane of the mouth, pharynx and branchial arches, often extending backwards as far as the opening of the œsophagus. In some species they are wanting from the roof of the mouth and pharynx

in others they are absent from both the roof and floor of the mouth and pharynx and are restricted to the pharyngeal margins of the branchial arches; while in one species he found that denticles have ceased to be developed in the pharynx except on the hyoid and first branchial arch, but, are retained over a considerable area on both the roof and floor of the oral cavity. In a few species denticles have become lost altogether. Since there exists this variation in the distribution of the denticles in the oro-pharyngeal cavity of elasmobranchs, Imms ('05, pp. 47–49) offered the suggestion that these structures are vestigial organs and that the primitive method of distribution is represented in the ancestral forms of existing elasmobranchs, that is, those species in which they are uniformly distributed throughout the oral and pharyngeal cavities. In order to account for the variations in the distribution of the denticles, which are met with in other species, he proposed that they have been derived from this primitive condition through their becoming restricted to certain areas only. He suggested, furthermore, that, although we know nothing concerning the habits of the ancestral vertebrates or for what particular mode of feeding the structure of their mouth was adapted, "it is possible that the seizure, holding, or perhaps even the crushing of the food may have been effected by the movements of the ventral portions of the arches towards the roof of the oral cavity, after the fashion of the hypopharyngeal teeth in connection with the hinder branchial arches in many Teleosts. If there be any truth in this suggestion, it will not be difficult to appreciate the physiological value of an extensive distribution of denticles over the greater part of the oral and pharyngeal mucous membrane in the primitive Vertebrates. With the evolution of special jaws at a later period, the functional denticles would naturally tend to become restricted to them and constitute ordinary teeth, leaving, however, the residue of the stomodael invasion of dermal denticles to become pharyngeal teeth, or gill-rakers, or to remain as vestigial structures, or to vanish altogether." These suggestions are of interest in that they not only emphasize the idea of an extensive ectodermal migration during ontogenetic development but they also offer an explanation for the phylogenetic origin of pharyngeal teeth.

Following up the theory of ectodermal migration in to the oro-pharyngeal cavity, some investigators propose that this region in fishes belongs morphologically to the integument.

O. Hertwig ('74, page 393) maintained that, inasmuch as placoid scales and teeth are known to arise only from ectoderm, and, since they may be distributed throughout the whole of the oro-pharyngeal cavity even up to the commencement of the œsophagus, therefore, this region does not belong to the gut proper but to the outside integument ("die Mund und Schlundöhle nicht dem Darmtractus sondern noch dem äussern Integumente ängehort)." Jacobshagen ('11, '12) likewise supports this view. In order to support this hypothesis, he offered the following evidence: (1) the pharynx possesses an epithelial lining of the nature of epidermis, (2) it is provided with striated muscle, and (3) the presence of such ectodermal derivatives as placoid scales, teeth and taste buds. He held, that, since no such structures as taste buds and teeth have been demonstrated as occurring in a single place of the vertebrate body which is of proven endodermal origin, therefore, the entire foregut belongs to the ectoderm ('11, p. 568 "dass der gesamte Vorderdarm dem Ektoderm ängehort"). Fahrenholz ('15) studied the distribution of placoid scales in the oro-pharyngeal cavity of various species of elasmobranchs and employed the fact of their presence in this region as evidence to support the above mentioned hypothesis. He held that, since there is a sharp cessation of dermal denticles at the commencement of the œsophagus in most of the species examined, therefore, this region of fishes is ectodermal.

Moroff ('02, '04) was, perhaps, the first investigator to furnish any conclusive evidence for the migration of ectoderm into the pharyngeal cavity of fishes. He claimed that in the development of the gill-slits of fishes ectoderm not only plays the leading role but that it also forms the lining of the gill-slits in adult fishes and even extends into the pharynx. Moreover, he offered the suggestion that this explains why teeth and placoid scales are found on the pharyngeal bars of certain fishes, since, as he pointed out, according to all observations entoderm does not possess the ability to form teeth ('04, p. 205 "das Entoderm nach allen Beobachtungen keine Zähne zu bilden imstande ist").

The idea of ectodermal migration to account for the occurrence of pharyngeal teeth in teleosts and placoid scales on the branchial arches of elasmobranchs is also suggested in some text-books. Thus, Tomes ('23, p. 3), in referring to the problem of the origin of pharyngeal teeth, said "the probable

explanation of many of the teeth in these positions is that they are derived from lateral invaginations of the epiblast similar in character to the anterior stomodaeum." He adds, however, that this is not certain and that this explanation cannot apply to all the tooth-like structures found in these and "some other positions, for example, those found in the œsophagus of certain fishes (family Stromatidæ) which are situated in positions quite beyond the limits of epiblastic invaginations." Lankester ('09, p. 58) states that the possession of a dermal exoskeleton is a characteristic feature of the Gnathostomata and that it first appears in the form of small tooth-like structures scattered all over the skin. He goes on to explain, with more certainty than is usually manifest, "since the skin grows inwards at the mouth and gill-slits, denticles may be found also inside the buccal cavity, and on the inner surface of the gill-bars."

Some investigators, on the other hand, not only deny any evidence of a posterior migration of the ectoderm after the rupture of the oral plate or of a lateral migration by way of the pharyngeal clefts but also take the view-point that endoderm possesses the capacity per se to form these so-called ectodermal derivatives. Dohrn ('82, '84) not only denied the ectodermal nature of the foregut of fishes and claimed that the whole domain of the oro-pharyngeal cavity as well as its derivatives are developed from endoderm but also disagreed with the conception of an ectodermal invagination during the formation of the mouth and gill slits. Kerr ('02) also denies the necessity of an ectodermal contribution in the development of the teeth of vertebrates. He claimed ('02, p. 424) that in Lepidosiren paradoxa "the tooth germs begin to appear before there are any traces of a lumen in the buccal cavity." Cook and Neal ('21), after a critical study of the successive stages of embryos of Squalus acanthias, claimed (p. 48) "that the pharyngeal cavity is endodermal in its origin and there is little or no inward migration of the ectoderm into the pharynx." In regard to the capacity of the endoderm to form placoid scales in the pharynx of these fishes, they conclude that "endoderm, therefore, it would appear, may give rise not only to sense organs, but to scales which are usually conceived as ectodermal in origin."

Miss Adams ('24) claims that some potentiality for the formation of teeth exists in the endoderm of Amblystoma. In summarizing the results of her study of the stages in normal development of the mouth and tooth germs, she says (p. 361)

that they "demonstrate the presence of endodermal as well as ectodermal enamel organs in the tooth germs of Amblystoma punctatum." As to the significance of these endodermal enamel organs, she points out that the existence of teeth similar in structure, but with enamel organs derived on the one hand from ectoderm and on the other from endoderm, raises the question of the specificity of the germ layers.

Jenkinson ('06), likewise, implies doubt as to the strict specificity of the germ layers. He points out that "muscles, for example those of the skin-glands in Amphibia, may be derived from the ectoderm, and enamel is said occasionally to arise from mesodermal tissue." According to this author, the facts of descriptive embryology might well be deemed sufficient of themselves to warrant us in relinquishing any hope of retaining the morphological significance which for so long has been attached to the germ layers. He is of the opinion that "the germinal layers are not sets of cells universally identical in origin which necessarily and invariably give rise to certain fixed parts of the adult organization, but merely convenient terms for the primordia of the structures of the adult."

Whereas the idea of ectodermal migration to account for the presence of scales and teeth in the pharyngeal cavity of fishes is suggested in some text-books, the thought is implied in others that these structures could have formed from endoderm in situ. Thus, Balfour ('80, p. 638) states that "although the teeth are to be regarded as primitively epiblastic structures, they are nevertheless found in Teleostei and Ganoidei on the hyoid and branchial arches: and very possibly the teeth on some other parts of the mouth are developed in a true hypoblastic region." Wiedersheim ('86, p. 483) points out that in many cases teeth are met with in parts of the oral cavity where they could have been formed only from endoderm ("wo sie sich nur aus rein entodermalen Boden herausgebildet haben können."). Wortman ('87), in describing the development of the teeth of vertebrates from the invaginated stomodael ectoderm, mentions that in many fishes teeth are found far back in the pharynx and, therefore, beyond the limits of the invagination of the integument. He goes on to add, on the authority of Prof. J. A. Ryder, whose statements he considered highly authoritative due to his extensive knowledge of the embryology of fishes, that these teeth "are truly of hypoblastic derivation. If this be true, the generalization that all teeth are modified dermal spines is certainly incorrect."

It is evident, therefore, that the doctrine of the specificity of the germ layers is occasionally doubted and that the literature dealing with the question of the origin of such structures as the pharyngeal teeth of fishes includes more or less speculation. It is striking how varied are the opinions of investigators and how, oftentimes, their interpretations appear diametrically opposed with regard to this problem. In view of this uncertainty in the interpretation of the origin of pharyngeal teeth of teleosts, Prof. Raymond C. Osburn of the Department of Zoology, Ohio State University, suggested to the writer that he undertake an investigation to attempt to determine from which germ layer the pharyngeal teeth of the carp (Cyprinus carpio Linnaeus) originate. The writer wishes to express his indebtedness to Prof. Osburn who offered many helpful suggestions and kindly criticisms. Thanks are also due Mr. E. L. Wickliff of the Ohio Division of Fish and Game and the employees of the U. S. Bureau of Fisheries at Put-in-Bay, Ohio, through whom the material used for this problem was obtained.

Material and Technique.

Three embryological series of *Cyprinus carpio* were employed in the present investigation. Series 1 was obtained in June 1925 at Buckeye Lake, Ohio by collecting eggs which had been fertilized under natural conditions. The eggs of the carp are pale yellowish in appearance and of such translucency as to be easily overlooked in the water. They are perfect spheres and after being in the water for some time swell to about 2 mm. in diameter. When expressed from the body of the ripe female they are extremely adhesive, and, when fertilized in shallow water are often found adhering to aquatic vegetation. These were collected and were supplied with running water from the lake the mean temperature of which was 69.8° F. The age of the embryos was calculated from the time of hatching, since it was impossible to determine the time of fertilization. Specimens of various stages were preserved every hour from the time of hatching up to the age of 72 hours. Thereafter, they were taken at various intervals of 2, 4 or 8 hours for the next 7 days. The remaining specimens were taken daily until 20 days after hatching. The yolk sac was absorbed by the end of the fourth day after hatching. In order to insure normal growth and development, artificial feeding was carried out with plankton

organisms obtained from the lake by means of a tow net, since larval carp are largely plankton feeders. Series 2 and 3 were obtained in June 1926 and '27, respectively, from the carp hatchery which is conducted by the U. S. Bureau of Fisheries at Port Clinton, Ohio. The eggs, after being fertilized artificially by stripping the ripe males and females, were placed in hatching jars. Thus it was possible to have exact data as to the time of fertilization and also as to the age of the developing embryos. In series 2 specimens were preserved every hour from the time of fertilization up to 80 hours after fertilization. In series 3 they were also taken at hourly intervals from 59 hours after fertilization to 160 hours after fertilization.

The period of incubation depends upon the temperature of the water. In series 2 it was 78 hours after fertilization with the temperature at 69° F. and in series 3 it was 88 hours after fertilization with the temperature at 65° F. It is apparent that stage 88 in series 3 is equivalent to stage 78 in series 2, since both represent the same stage of development in that the larvæ are just hatched. As stated above, it was impossible to determine the time of fertilization in series 1. Inasmuch as the temperature of the water during the development of this series was practically identical with that in series 2, and, since the eggs, which were collected in the same locality, hatched between 3 and 4 days after they were placed in running water it has been assumed that stage 1 in series 1, that is those which have just hatched, is equivalent to stages 78 and 88 in series 2 and 3 respectively. Hence, it is possible to supply any missing stages in any of the series if the other series is complete at that point, and, in this manner, to have an uninterrupted series of embryos from the time the eggs were fertilized until 20 days after hatching.

The eggs were fixed in Bouin's fixing fluid or in corrosive sublimate plus 10% acetic acid—Child's method. The embryos up to the time of hatching were removed from the egg membrane before embedding in order to allow greater penetration of the reagents. To facilitate orientation in the processes of embedding and sectioning the younger stages of embryos were stained in toto with eosin. They were embedded in parafin (M. P. 54° C.) and cut in sagittal, transverse and frontal sections of 10 mu. Various stains were employed, but, Delafield's hematoxylin with eosin as a counterstain proved the most satisfactory for clearness of delineation.

In order to determine the germ layer from which the pharyngeal teeth of the carp originate it was necessary to study the mode of formation of the foregut, since the solution of this problem hinges on the derivation of the pharyngeal mucous membrane. For this purpose the series of carp embryos were examined with the view to ascertaining whether or not there is any evidence of migration of ectoderm into this region during development. In order to determine this it was necessary to work out the method of development of the mouth and gill-slits. After having determined the derivation of the mucous membrane of the pharynx, the method of development of the pharyngeal teeth was studied with the view to determining the germ layer from which the enamel organs take their origin.

Many difficulties were encountered in attempting to solve this problem, most of which involved methods of technique. Orientation of the embryos in the embedding material, in order to obtain sections through the proper plane, proved difficult even though the material was first stained in toto. This difficulty made it necessary to section large numbers of embryos before obtaining the proper plane. A considerable number of fixing and staining reagents were tried before satisfactory ones were found, since many fixing solutions cause the yolk to become hard. This hardening of the yolk hampered sectioning, especially in the early stages, as the yolk has a decided tendency to "shell-out" of the parafin ribbon. Many attempts to dissect away the yolk sac before embedding proved unsuccessful, since the yolk was oftentimes so exceedingly hard and the embryos were so fragile. This difficulty was finally overcome to a large extent by placing the eggs, which had been fixed in Bouin's fluid, for a short time in 35% alcohol plus acetic acid, since this tends to soften the yolk. Child's method of fixation also improved this hardening condition.

It was difficult at first to distinguish the boundaries of ectoderm and endoderm in the oro-pharyngeal cavity after the formation of the oral and pharyngeal clefts. Attempts were made to find a stain which would tend to differentiate these layers. The nearest approach to such a differentiation was obtained by staining heavily with Delafield's hematoxylin and destaining by means of acid-alcohol, in which case the ectoderm remained more heavily stained than the endoderm. Intra-vitam stains, such as methylen blue and neutral red, were tried with the idea in mind of staining the ectoderm before it

invaginated to form the oral and pharyngeal clefts. It was hoped that the ectoderm could thus be traced inward in later stages. However, these attempts proved unsuccessful, since these stains are so readily soluble in alcohol in spite of various attempts at fixation. Golovine's method ('02) of fixing neutral red gave promise of success, but, because of the extreme difficulty of maintaining the proper temperatures attempts to use it met with failure.

Origin and Development of the Foregut.

In order to determine exactly what germ layers contribute to the formation of the mucous membrane of the foregut it was necessary to study its development from the earliest stages of germ-layer differentiation. The first evidence of differentiation of the germ layers of the carp was observed 10 hours after fertilization (Fig. 1). At this time the superficial layer of cells of the blastoderm became differentiated by flattening to form what will later become the "epidermal stratum" or covering layer of the epidermis. Subsequent stages show that this layer gradually becomes reduced to a thin membrane which stains deeply. No evidence could be found of its having taken part in the process of gastrulation to form the inner germ layers.

Gastrulation. This process was observed to occur in the carp in the same manner as that described for the Sea-bass (*Serranus atrarius*) by Wilson ('89, p. 218). By 12 hours after fertilization (Fig. 2) the cells at the edges of the blastoderm had formed a well-marked thickening. This thickening could be recognized round the whole of the periphery of the blastoderm, however, at the posterior middle point, which becomes the tail end of the future embryo, it was more pronounced than elsewhere. One hour later (Fig. 3) a sheet of cells, consisting of two or three cell-layers, terminating anteriorly with a free margin, had grown forward from this point. This point is, of course, the dorsal lip of the blastopore. The ingrowing cellular layer is known as the "primitive hypoblast" from which are later differentiated the endodermal and mesodermal layers. The superficial portion of the blastoderm may now be called the ectoderm. It consists at this stage of two well defined layers, the outermost flattened layer or epidermal stratum and an inner layer of three to five strata of closely packed polygonal cells—the so-called sensory or nervous layer.

By 19 hours after fertilization (Fig. 4) the embryo was distinctly marked out as a median longitudinal thickening of the blastoderm. The anterior pole of the blastoderm has grown forward until it has completely invested the yolk sac. It has already reached the posterior pole of the blastoderm and thus forms the ventral lip of the blastopore. The mass of cells which make up this anterior pole or ventral lip was described by Wilson ('89, p. 226) for the Sea-bass as the "secondary caudal mass" which, according to him, "serves as cellular material for the backward growth of the several organs." The closure of the blastopore has not been completed at this stage as is evidenced by the yolk plug. The future head region of the embyro has already begun to be marked off as a thickening of the ectoderm at the anterior region of the embryonic area. The thin sheet of ectodermal cells, which connects the head region and the secondary caudal mass, is the non-embryonic area of the blastoderm. It forms an investment for the yolk sac and is continuous with the ectoderm which covers the embryo. The primitive hypoblast has extended forward until its anterior free margin has come into contact with the ectoderm in front of and ventral to the future fore-brain. It is everywhere clearly marked off from the overlying ectoderm, with the exception of its posterior extremity where it bends round into and blends with the ectoderm at the dorsal lip of the blastopore. For some distance anterior to the blastopore it consists of three to four strata of more or less polygonal cells. As it proceeds anteriorly it gradually becomes reduced to two strata and in the region of the future fore-brain it is only indistinctly divisible into two layers. Flattened cells appear here and there ventral to the primitive hypoblast and in close contact with the yolk. These flattened cells represent the first evidence of endoderm.

The process of endodermal differentiation can best be made out in figure 5, which is a transverse section through an embryo 21 hours after fertilization. The primitive hypoblast has divided on each side of the middle line into two plates of cells, an upper consisting of two to three strata of polygonal cells and a lower unicellular layer of flattened cells. The upper layer of cells represents the mesoderm, which is seen to be made up of separate halves, one on each side of the middle line. The lower flattened layer is the endoderm, which lies in close contact with the yolk. The cells in this layer are observed to

approach a columnar shape in later stages. The median tract of cells has already separated as the primordium of the notochord.

The process of endodermal-mesodermal differentiation was observed to begin in the posterior region of the embryo and to proceed gradually forward. By 23 hours after fertilization (Fig. 6) the endoderm is completely established as a connected unicellular layer, the anterior extremity of which extends up to and comes into contact with the ectoderm near the angle formed by the lower forepart of the head and the anterior ectodermal wall of the yolk sac. The entodermal cells have maintained their flattened appearance in the future brain region. However, they have already begun to assume a columnar shape in the pharyngeal region, which can readily be identified by means of the otic vesicle. The endodermal cells can easily be distinguished from the mesodermal cells, which are polygonal in shape except in certain portions of the head region where they appear as scattered mesoblast cells. The primordium of the foregut is thus established rather early in development. It is evident that up to this time it is unquestionably endodermal in origin, since no openings have been established and consequently no ectodermal migration could have occurred.

A study of the subsequent history of the foregut of the carp reveals some features which are peculiar in a number of respects: (1) the original unicellular layer of endoderm is transformed into a solid cord, which is at first considerably depressed, by a process of folding; (2) a lumen is gradually established by a separation or retreat of the endodermal cells; (3) the oral end of the foregut appears to be developed from behind forwards without any clear evidence of a stomodaeum. In figure 7, which is a transverse section through the pharyngeal region of an embryo 30 hours after fertilization, the endodermal layer is recognizable by means of the columnar shape of its cells. It passes ventral to the primordia of the brain and notochord, on either side of which it rises to form a fold which is directed laterally and dorsally. These obliquely directed folds represent the pharyngeal folds which later contribute to the formation of the gill-slits. From a study of successive stages the base of each fold is seen to grow toward the median line where it fuses with its fellow of the opposite side thus closing in the foregut ventrally. The foregut then consists of

two rows of cells, a dorsal and a ventral, which are at first pressed against each other without any evidence of a lumen between them. This depressed condition of the foregut is no doubt the result of the pressure exerted by the excessive growth of the overlying brain which tends to mold it upon the yolk sac.

Later scattered lumina appear here and there between the two rows of cells. These unite eventually thus establishing the lumen of the foregut. With the appearance of this lumen the endoderm was observed to assume the same structure as the ectoderm, that is, it appeared to be composed of two layers of cells, an inner layer composed of flattened, pavement-like cells and an outer layer of regularly arranged columnar cells. This observation agrees with that of Moroff ('02, p. 336) for Trutta fario. The appearance of this inner flattened layer in the lumen of the foregut raises the question as to its origin. Is it derived from the outer columnar layer by a process of division or delamination or does it represent ectoderm which possibly migrates into this region? In order to answer these questions it was necessary to study the method of formation of the mouth and gill-slits.

A. FORMATION OF THE GILL-SLITS.

Investigators are not in accord as to the exact method of the formation of the gill-slits in fishes. It is generally agreed, however, that the primordia of these clefts arise by paired, obliquely directed folds of the pharyngeal endoderm coming into contact with lateral invaginations of the ectoderm, and, that openings are established by the rupture of the closing-plates which are formed at the point of fushion of the ectoderm and endoderm. The diversity of opinion is in regard to the germ layer which plays the leading role in the process and to the layer or layers which form the lining of the gill-slits in adult fishes. Dohrn ('82, '84) claimed that in Belone embryos the ectodermal invaginations and the endodermal evaginations are simultaneous, but, that the latter are more pronounced, so that the greater part of the lining of the gill-slits is derived from endoderm. Cook and Neal ('21, p. 49) and Balfour ('78, p. 49) agree that in elasmobranchs the endoderm is the active layer in the formation of the gill-slits and that it serves as their lining. Balfour described the method of formation of the gill-slits in these forms as an outgrowth of the pharyngeal

endoderm which "meets the passive external skin, coalesces with it, and then, by the dissolution of the wall separating the lumen of the throat from the exterior, a free communication from the throat outwards is effected . . . . . . Thus it happens that walls lining the clefts are entirely formed of hypoblast." He hastened to add that "it should be remembered, however, that after the gill-slits become open, the point where the hypoblast joins the epiblast ceases to be determinable, so that some doubt hangs over the above statement."

Greil ('06), who made a comparative study of the method of development of the gill-slits in Elasmobranchs, Ganoids, Dipnoi and Teleostei, maintained that the ectoderm plays a passive role in the process of gill formation, that it becomes indistinguishable where it blends with the endodermal evaginations, but, that the epidermal stratum grows inward and forms the inner lining of the gill-slits (p. 268 "die Kiemenspalten an ihren Oberflächen von einer ektodermalen Zellschichte überkleidet sind."). According to Moroff ('02, '04) the ectoderm plays the leading role in the development of the gill-slits of Trutta fario. On the other hand, he agrees with Greil that the ectoderm migrates inward to furnish the lining of the gill-slits. He claims, moreover, that the ectoderm continues to grow inward to the pharyngeal cavity. As pointed out in the Introduction, this was his explanation for the origin of placoid scales and teeth which sometimes occur in this supposedly endodermal territory. Oellacher ('73, p. 79), Göette ('01, p. 566), Lankester ('09, p. 58) and Kingsley ('26, p. 270), likewise, support the view that the gill-slits of fishes are lined with an invagination of the integument. Kingsley concludes his description with the remark that "the matter is one of great difficulty, and cannot be regarded as settled." With this thought in mind, and in spite of the fact that the weight of the evidence favors the idea of ectodermal migration by way of the gill-slits, it was deemed necessary to study the method of development of the gill-slits in the carp in order to determine exactly whether or not ectoderm does migrate inward to the pharyngeal cavity by this route.

It was ascertained from a study of transverse sections through the pharyngeal region of the series of carp embryos that six pairs of pharyngeal clefts develop in a consecutive order from anterior to posterior. The most anterior pair, the hyomandibular, which intervenes between the hyoid and mand-

ibular arches, closes soon after its formation and is thus obliterated. Behind this there are five pairs of clefts which form a similar number of gill-slits. Inasmuch as the method of development of the five pairs of pharyngeal clefts is essentially comparable a description of the hyo-branchial or first pair, which intervenes between the hyoid and first branchial arches, should suffice as a means of determining what part the ectoderm plays in their formation.

The gill-slits were observed to arise according to the manner generally described by the majority of investigators for the various forms of fishes, that is, by lateral folds of the pharyngeal endoderm fusing with similar invaginations of ectoderm. The first evidence of the pharyngeal fold, which will assist in the formation of the first gill-slit, was found 30 hours after fertilization (Fig. 7). The position of this fold, ventral and slightly posterior to the otic vesicle, is relatively constant throughout development. The further course of its development will be evident if figure 7 be compared with figures 8 to 15. Whereas the fold had just begun to form 30 hours after fertilization, it was well marked out 2 hours later (Fig. 8). At this stage the apex of the fold has extended laterally and dorsally until it has come into contact with the inner cells of the ectoderm. The latter is recognizable by means of its superficial layer of flat cells, the epidermal stratum, and its inner layer of cuboidal cells, the so-called nervous layer. On the other hand, the endodermal cells, which make up the pharyngeal fold, are columnar in shape, and, are regularly arranged in rows. The two rows of endodermal cells are firmly applied against each other without any trace of a lumen between them. There is no evidence as yet of a simultaneous invagination of the ectoderm, although its inner layer has thickened somewhat at the point where it comes into contact with the apex of the pharyngeal fold. Thus far, at least, the endoderm has, apparently, taken the leading role.

By 35 hours after fertilization (Fig. 9) the inner layer of the ectoderm has thickened considerably at the point of contact with the pharyngeal fold. The latter is still recognizable by means of the regular arrangement of its columnar cells in two rows. The inner ectodermal cells are irregularly arranged and are seen to cover the apex of the pharyngeal fold in a cap-like fashion. Apparently, the outer layer of ectodermal cells has begun to invaginate as is evidenced on one side by a slight

depression at the external surface. One hour later (Fig. 10) the inner layer of the ectoderm was observed to penetrate the apex of the pharyngeal fold as is evidenced by the wedge-shaped plug of cells which can be seen entering the endodermal fold at this point.

In figure 11, which is a transverse section through the pharyngeal region of an embryo carp 39 hours after fertilization, the apex of the pharyngeal fold has become continuous with the inner layer of the ectoderm so that it is no longer possible to determine the boundary between endoderm and ectoderm at this point. Furthermore, a slight cleft-like lumen has appeared in the outer portion of the pharyngeal fold into which the epidermal stratum dips slightly thus forming a shallow funnel-shaped depression at the surface. This potential opening represents the primordium of the first gill-slit.

An examination of subsequent stages reveals that the epidermal stratum continues to grow inward as rapidly as the cleft-like lumen proceeds inward to the pharyngeal cavity. This is evidenced in figure 12, which is a tranverse section through the region of the first gill-slit of an embryo 56 hours after fertilization, by flattened epidermal cells lining the lumen. These are seen to stop abruptly at the point where they come into contact with the depressed foregut which is still in the solid stage. The connection of these flattened cells with the epidermal stratum is readily recognizable at the surface. They are easily distinguished from the original endodermal cells, since the latter are columnar in shape and are regularly arranged in rows. Figures 13, 14, 17 and 18 also present evidence of the migration of the epidermal stratum inward to the pharyngeal cavity. Figure 17 is a photograph of a sagittal section through the pharyngeal region 57 hours after fertilization in which is shown the character of the cells lining the first gill-slit. The section was cut far laterally and consequently the connection of the gill-slit with the foregut cannot be made out. The cell outlines are more or less indistinct, however, flattened cells, which are stained heavily, can be recognized lining the lumen of the gill-slit. These cells are continuous with those on the external surface. The latter appear pavement-like with a large central nucleus as can be seen above and to the right of the external opening of the gill-slit. Figure 13 shows the entire anterior portion of the same embryo as in figure 17 with only the region of the first gill-slit drawn in detail. This was done

under oil immersion for the purpose of demonstrating the relation of the flattened cells, which line the lumen of the gill-slit, to the underlying columnar cells of the endoderm as well as to establish their connection with the epidermal stratum. Figure 14 is a transverse section through the region of the first gill-slit 78 hours after fertilization. The fore-gut as well as the first gill-slit has developed a rather spacious lumen. Not only has the lumen of the foregut become continuous with that of the gill-slit but also the flattened cells, which line the lumen of the latter, pass inward to form the lining of the pharyngeal cavity. These inner flattened cells are identical in appearance with those on the external surface with which they connect. They are easily distinguished from the underlying endodermal cells which are columnar in shape and uniformly distributed. In figure 18, which is a photograph of a sagittal section through the anterior portion of an embryo 80 hours after fertilization, all of the pharyngeal clefts have formed. They appear very much crowded together antero-posteriorly with only narrow cleft-like lumina with the exception of the first or hyo-branchial cleft. Here, as in figure 14, a pronounced lumen has formed and its connection with the pharyngeal cavity is well shown. The flattened cells, which form the lining of this cleft, are seen to pass inward to the pharyngeal cavity where they spread out in all directions. These cells appear heavily stained and can be traced from the pharyngeal cavity outward to the external surface.

It is evident from these observations that the pharyngeal clefts in the carp are formed by pharyngeal folds extending dorsally and laterally until their apices come into contact with the inner cells of the ectoderm which respond by sending inward a wedge-shaped plug of cells. The latter ruptures the apex of the pharyngeal fold which then becomes continuous with the inner cells of the ectoderm. A potential opening is established at the external surface by the growing inward of the epidermal stratum. The latter thus furnishes the inner lining of the gill-slit, and, as it continues to migrate inward forms also the lining of the pharyngeal cavity. The lining of the lumen of the pharyngeal cleft as well as that of the pharyngeal cavity is, therefore, made up of two kinds of cells, an inner flattened layer and an outer columnar layer. Stages 30 to 78 were re-examined with the purpose of determining whether or not these flattened cells could possibly have been derived from

the underlying columnar cells by the process of division or delamination. No such evidence could be found.

As already indicated, the five pairs of pharyngeal clefts do not form simultaneously but develop in sequence from anterior to posterior, the most anterior of which is the first to arise. The remaining pairs of pharyngeal folds were examined with the view to ascertaining whether or not the characteristic flattened cells make their appearance in their lumina before the primordia of the clefts had been established. The course of development was traced as in the case of the hyo-branchial clefts from the time that the folds made their appearance up to the establishment of the primordial clefts. No evidence could be found in any of these where flattened cells appear in their lumina previous to the time when the ectodermal plug of cells penetrates the apices of the folds. Since these flattened cells are of the same character as those in the epidermal stratum, and, since the latter has been shown to extend gradually inward by way of the pharyngeal clefts to the lumen of the pharynx they are undoubtedly ectodermal in derivation. It is negligible, therefore, whether or not ectoderm migrates into the oro-pharyngeal cavity of the carp by way of the mouth, since the inner lining of the pharynx has been demonstrated to be derived from the epidermal stratum which has migrated inward by way of the gill-slits. Nevertheless the method of development will be briefly outlined, since there are some features of considerable interest in connection with its development.

B. FORMATION OF THE MOUTH.

In the higher vertebrates the endoderm is said to form a simple tube, the anterior extremity of which terminates blindly near the anterior end of the body on the ventral side. It is generally conceived that the ectoderm invaginates to form an oral pit or stomodaeum the posterior boundary of which comes into contact with the blind anterior extremity of the foregut thus forming an oral plate. Eventually this ectodermal-endodermal plate ruptures thus establishing the mouth.

According to some investigators the mouth in teleost fishes does not arise in this supposed typical fashion but develops in a manner peculiar to this group. Dohrn claimed, supporting his statements by figures, (Dohrn '82, Plates XV and XVI) that the mouth in Belone, Labrus merula, Gobius, etc. arises in a manner comparable to that of the gill-slits. In his description

of the development of the mouth in these forms he points out the following features: (1) the anterior extremity of the depressed foregut sends out a pair of obliquely directed folds which extend laterally and come into contact with the ectoderm as in the case of the pharyngeal folds situated more posteriorly; (2) clefts form here in the same manner as in the pharyngeal region so that the mouth of teleosts therefore, opens laterally; (3) in the meantime, the anterior extremity of the foregut continues to grow forward until it comes into contact with the inner cells of the ectoderm in the midline ventral to the primordium of the fore-brain; (4) the ectoderm which covers the anterior extremity of the foregut breaks through without any evidence of a stomodaeum. Ryder ('84, p. 529), likewise, supported this view. In reference to Dohrn's contention that the mouth in teleosts is formed by outgrowths, which grow laterally, he stated, "I have seen evidence in a series of embryo Clupeoids which have inclined me to think Dohrn's view the correct one." He was likewise unable to find any trace of a stomodaeum in these forms.

Apparently it is generally assumed that the mouth in teleost fishes develops according to the typical vertebrate method. Most investigators have been concerned with the larval and post-larval development, and, a few have studied the histological changes in the epithelial lining accompanying this development. Stewart ('26) implies, at least, that the mouth in Castostomus commersonii develops in a manner similar to that of higher vertebrates. He described the mouth in the newly hatched larva as being in the oral pit stage and that it does not open until some time after hatching. He mentioned that after the mouth opens the oral and pharyngeal cavities "are lined with a stratified epithelium, the cells of which are rounded, some of the superficial cells being flattened." Wilson ('89) dismissed the problem of the formation of the mouth in Serranus by merely stating that "the mouth breaks through a couple of days after hatching." He, likewise, pointed out that "shortly after the mouth appears, the cells which line the alimentary canal lose their embryonic appearance and come to look much like an adult mucous membrane."

In the carp the mouth breaks through in the angle formed by the lower fore part of the head and the anterior ectodermal wall of the yolk sac. By 79 hours after fertilization (Fig. 19) the foregut has acquired a spacious lumen. From a study of

preceding stages it was ascertained that this lumen develops from posterior to anterior and that it is formed by a retreat or separation of the dorsal and ventral rows of columnar cells which make up the depressed foregut. The mouth has not opened at this stage as is evidenced by the plate of cells which forms the anterior boundary of the foregut. One hour later, however, this oral plate (?) ruptures thus forming the mouth. As can be seen in figure 19 there is no evidence of a stomodaeum at the point where the mouth breaks through. It is true that the angle between the head and the yolk sac—the point where the mouth breaks through—has deepened considerably during development, however, this deepening is not due to an invagination of ectoderm, since there is little evidence of cellular activity, but rather to the forward growth of the head. It is evident from these observations that the statements of Dohrn and Ryder concerning the lack of a stomodaeum in certain teleosts also hold true for the carp. Moreover, as Dohrn maintained, the opening of the mouth occurs from within to the outside.

With the establishment of the mouth the ectoderm becomes continuous at the lips with the inner lining of the oral cavity. It may be assumed, however, that the inner lining of the oropharyngeal cavity is of ectodermal origin before the mouth breaks through, since it has been demonstrated that the epidermal stratum grows inward by way of the pharyngeal clefts to the pharyngeal cavity where it forms its inner lining. These flattened epidermal cells and their relation to the underlying columnar cells can readily be made out in the lumen of the foregut posterior to the oral plate.

An examination of the series of carp embryos also furnishes some evidence to support the views of Dohrn and Ryder as regards the mouth resembling a pair of fused gill-slits in its origin. In figure 15, which is a transverse section cut near the posterior boundary of the optic vesicles 27 hours after fertilization, the endodermal layer, recognizable by the columnar shape of its cells, rises up on either side of the primordium of the fore-brain to form a lateral fold. The apex of the fold on one side has already come into contact with a proliferation of the nervous layer of the ectoderm. The subsequent history of these folds parallels that of the pharyngeal folds as is evidenced in figures 16, 20 and 21. Figure 16 is a sagittal section cut far laterally through the anterior region of an embryo 59

hours after fertilization. Slightly posterior and ventral to the eye is a two-layered fold of columnar cells, the so-called oral fold, which extends obliquely downward and forward to the ectoderm in the angle between the head and the yolk sac. The boundaries of the columnar cells, which are presumably endodermal, and the inner ectodermal cells are no longer distinguishable. A potential opening appears to have been established in the angle between the head and the yolk sac as is evidenced by a slight indentation of the epidermal stratum at this point. In figure 20, which is a photograph of a sagittal section cut far laterally from the same specimen as in figure 19, the epidermal stratum is migrating inward by way of the oral fold, as is evidenced by the thin, heavily stained layer which is interposed between the two rows of columnar cells which make up the fold. Figure 21 is a photograph of a transverse section cut far anteriorly through the same embryo as in figure 14. A fold of columnar cells is seen lying ventral to the eyes and extending laterally to the inner layer of the ectoderm with which it is continuous. The oral end of the foregut is somewhat depressed, however, a slight lumen can be made out which is lined with flattened cells. Although their continuity with the epidermal stratum is not clearly visible in this figure, the same could be made out when examined under oil immersion.

It appears evident from these observations that the mouth of the carp develops in a peculiar manner as compared with that of higher vertebrates. It is questionable whether or not it represents a pair of fused gill-slits or that it merely resembles a pair of gill-slits in its origin. Wilder ('23, p. 296), in discussing the origin of the vertebrate mouth, suggested "that in some form midway between the lamprey eel and the shark the habit arose of seizing and taking in food by the anterior gill-slits, the edges of which, provided with sharp, pointed scales, served better for the retention of their living prey than did the oral hood and horny teeth of the actual mouth." He suggested, moreover, that the continuance of this habit eventually gave rise to the vertebrate mouth, formed by the ventral fusion of the two lateral gill-slits, and to the jaws, formed by the movable gill-arches which were armed with placoid scales. This hypothesis has not received much attention, chiefly, because, it does not show that way in the lowest fishes. Since teleosts are a long way from being primitive, the question

arises does the mouth of teleosts represent a recapitulation or a specialization?

The significance attached to the results of these observations on the development of the mouth of the carp, aside from the evidence that it opens from within outwards, apparently lacking a stomodaeal invagination, and that it appears to resemble a pair of fused gill-slits in its origin, is that it serves as an avenue for entrance of the ectoderm into the oro-pharyngeal cavity. Whether or not these ectodermal cells migrate posteriorly into the pharynx is impossible to determine, since, as already indicated, ectodermal cells migrate inward to the pharyngeal cavity by way of the gill-slits before the mouth is established.

It was ascertained from an examination of later stages that the two types of cells, which form the lining of the oro-pharyngeal cavity, maintain their integrity throughout the further course of development of the foregut. These results are supported by Pictet ('06), who investigated the histological structure of the alimentary tract of the adult carp. He described the mucous membrane lining the oro-pharyngeal cavity as being made up of two distinct layers of cells, an inner squamous and an outer or deeper layer of columnar cells. He found that in the remaining portions of the tract the mucous membrane is made up entirely of columnar cells which resemble those in the lowermost layer of the pharynx.

The evidence furnished by a study of the histological structure of the foregut as well as the embryological considerations presented in this paper are sufficient grounds to prove that the mucous membrane lining this region is composed of two types of cells each derived from a distinct source, an inner layer of flattened cells the presence of which is accounted for by migration of ectoderm, and, an outer layer of columnar cells which represents the original endoderm.

Having established the germ-layer origin of the pharyngeal mucous membrane, the next procedure is to study the development of the pharyngeal teeth with the view to determining which of these two layers of cells give rise to the enamel organs of the teeth.

Origin and Development of the Pharyngeal Teeth.

In the carp, as in all cyprinoids, the jaws are toothless. Teeth occur, however, on the inferior pharyngeal bones (ceratobranchials) of each of the fifth gill-arches for which reason they receive the name pharyngeal teeth. Figure 22 is a photograph of the fifth gill-arches of an adult carp showing the number, form and arrangement of these teeth. Each pharyngeal bone bears 5 teeth placed in three rows and arranged according to a 1, 1, 3 formula. Each tooth consists of a root, neck and crown and is firmly anchylosed to the bone. The masticatory surface is more or less oval in shape with 3 or 4 parallel and slightly serrated furrows.

According to all accounts of the development of the teeth of vertebrates, a tooth always forms in a so-called tooth-germ which consists of two portions, an enamel-organ and a dentine-organ. These two structures are said to be derived from two distinct sources, the former from the oral epithelium and consequently is said to be ectodermal in origin, whereas, the latter is formed from the underlying sub-mucous tissue and is, therefore, mesodermal in derivation. At the point where a tooth is about to be developed an invagination or proliferation of the epithelial cells into the underlying mesodermal tissue is always to be seen. As this cone of epithelial cells proceeds inward, a papilla arises from the mesoderm beneath which grows into it thus causing it to assume a bell-shaped form with the concavity directed downward. The peripheral cells of the mesodermal papilla are said to form the dentine of the tooth for which reason this portion of the tooth germ receives the name of dentine-organ. The enamel-organ is that portion of the tooth germ which is formed from the epithelium. It has been well established by investigators that the enamel-organ is derived from the lowermost layer of the epithelium and that the enamel, when present, is formed from the epithelial cells which immediately invest the dentine papilla.

Investigators have shown that although there are many differences of detail arising from the various situations in which teeth develop in fishes there is, nevertheless, a great uniformity which pervades all that have been examined, and, that the method of development agrees essentially with that of other vertebrates. O. Hertwig ('74), who established the homology

of the teeth of vertebrates with placoid scales of elasmobranchs, claimed that in sharks the placoid teeth are successional and that each tooth germ, so far as the enamel-organ is concerned, develops from a general tooth-band. In this respect, the development of placoid teeth harmonizes with that of the mammalian tooth. Tomes ('23, p. 149) pointed out that whereas in the elasmobranchs each tooth germ, so far as the enamel organ is concerned, is derived from the general tooth-band, in teleost fishes "each enamel-germ apparently often arises independently, and, as it were, de novo." Miss Carlsson ('94), on the other hand, stated that in teleosts an enamel-ridge extends uninterruptedly along the whole length of the tooth-bearing bones and that the teeth do not develop in a continuous series, but new ones appear from the unexhausted enamel-ridge between those already formed. According to Miss Degener ('24) the teeth of Amia calva develop in essentially the same manner as placoid scales, though they are developed throughout all layers of the mucous membrane. She considers these placoid scale-like structures as representing intermediate steps between the lowest and highest forms of fishes. Röse ('94) distinguished three stages of tooth development in fishes: the first he called the free papilla or placoid stage, in which the primordia of the teeth develop in the mucous membrane in the same manner as placoid scales; the second he designated as the cone stage, in which the mucous membrane sends downward a separate tooth germ for each tooth primordium; the third or permanent stage is characterized by a dental ridge from which the teeth develop in the same way as those in higher vertebrates.

Although a considerable amount of investigation has already been carried out on the development of the pharyngeal teeth of the carp, a review of the literature failed to reveal any reference to the origin of these structures from the germ-layer viewpoint. It is quite significant that investigators, notably Heincke ('73), Friedman ('97) and Stoss ('21), are in agreement as to the origin of the enamel-organs from the lowermost cylindrical cells of the pharyngeal mucous membrane. These authors agree that the tooth germ forms by a proliferation of the lowermost layer of the pharyngeal epithelium which dips into the underlying sub-mucous tissue, and, that the latter responds by growing papilla-like into the under thickened end of the proliferated cone until it is surrounded like a cap by the epithelium.

In the present investigation the first evidence of an enamel-organ was observed in a larva 4 hours after hatching (series 1). Figure 23 is a photograph of a sagittal section through the pharynx showing the appearance of the enamel-organ as well as the mucous membrane lining this region. The latter can be seen to be composed of two distinct layers, an inner layer of irregularly arranged flattened cells and an outer or deeper layer of regularly arranged columnar cells. The primordium of the enamel-organ is recognizable as a crescent-shaped arrangement of cells. The boundaries of these cells have been outlined in ink for clearness of delineation. This portion of the tooth germ appears to be typical in that it is forming by an invagination from the pharyngeal epithelium. As regards the type and source of the cells which enter into the formation of the enamel-organ, the following significant facts are observed: the cells, which are arranged in a more or less orderly definite formation, are columnar in shape; these cells are not only similar to but are connected with the columnar cells which make up the lowermost stratum of the pharyngeal mucous membrane; the inner flattened layer of cells of the pharyngeal mucous membrane does not take part in the process of invagination but passes uninterruptedly over this point.

An examination of subsequent stages fails, likewise, to reveal any evidence of the inner flattened layer participating in the further development of the enamel-organ. In figure 24, which is a photograph of a sagittal section through the pharynx of a larva 18 hours after hatching, the tooth germ has advanced considerably in development. The dentine-organ has already begun to form as is evidenced by the rather large mesodermal papilla. The latter is invested by the enamel-organ which is recognizable as a bell-shaped structure made up of large columnar cells. The inner flattened layer of the pharyngeal mucous membrane can be readily made out in this figure. It appears as a continuous layer lining the pharyngeal cavity and does not seem to take part in the formation of the enamel-organ. By 25 hours after hatching (Fig. 25) the mesodermal papilla has increased in length considerably and has already begun to secrete a homogeneous matrix, the dentine of the future tooth. The enamel-organ has developed proportionately so that it has become folded upon itself thus converting it into a two-layered investing membrane. The columnar shape of the cells in the enamel-organ is very apparent in this figure and there

is no evidence of any flattened cells excepting those lining the lumen of the pharyngeal cavity. The continuity of the columnar cells, which make up the enamel-organ, with those in the deeper layer of the pharyngeal mucous membrane is shown at the point E. o... The columnar cells of the enamel-organ which immediately invest the dentine papilla have begun to assume a cylindrical form. The white area situated between these cylindrical cells and the tip of the dentine papilla suggests the presence of enamel. However, a careful examination under oil immersion failed to establish this point.

According to Tomes ('23, p. 149) the after-history of the enamel-organ depends much on the character of the tooth which is to be formed. If no enamel, or but a rudimentary coat of enamel, is to be formed, he claims, that the cells of the enamel-organ remain small and insignificant, whereas, if a partial investment of enamel is found upon the perfected tooth the cells of the enamel-organ attain a very considerable size opposite to the apex of the dentine-papilla, where the enamel cap is to be, and, that below this the investing cap of the enamel-organ becomes rudimentary. In figure 26, which is a photograph of a developing tooth 44 hours after hatching, the latter condition is suggested. The cells of the enamel-organ which immediately invest the apex of the dentine-papilla have attained a considerable size, whereas, below this point they have become greatly reduced. The dentine is now well marked out. Its apex appears to be capped with an enamel tip, however, this could not be absolutely determined. In the last analysis the question as to whether or not enamel is formed on these teeth is of no great importance in determining the main points under consideration, since, as Tomes ('23, p. 134) asserts, the presence of an enamel-organ is of universal occurence and is independent of any subsequent formation of enamel.

Discussion.

The problem of the specificity of the germ layers, especially as regards the potency of the endoderm and its capacity to form structures which are generally conceived to be derived from ectoderm, has long been a subject for investigation. As already indicated, investigators have attacked this problem from various angles. The adherents of the doctrine of the specificity of the germ layers, who hold that the presence of teeth in any

region is an accurate criterion for the existence of ectoderm in that region at some time in development, have employed the fact of the existence of teeth in the pharyngeal cavity of certain fishes, a region considered to be endodermal in origin, as evidence to support the hypothesis that ectoderm migrates into this region. Some merely assume that the ectoderm migrates posteriorly after the rupture of the oral plate, others that it arises from the invaginated ectoderm during the formation of the gill-slits. On the other hand, there are those who think that these so-called ectodermal derivatives arise in situ from the endoderm and deny any evidence of ectodermal migration either by way of the oral or pharyngeal clefts, at least not before the primordia of these structures are formed.

The problem of the germ-layer origin of the pharyngeal teeth of the carp, therefore, hinges on the mode of formation of the foregut as well as the derivation of its mucous membrane lining. The study of the development of the foregut shows that it is derived from endoderm which is completely established as a connected unicellular layer by 23 hours after fertilization. The results of the study of the method of development of the mouth and gill-slits present evidence that flattened cells from the epidermal stratum migrate inward to the oro-pharyngeal cavity and furnish its lining. The mucous membrane lining this cavity is, therefore, made up of two types of cells, each derived from distinct sources, an inner layer of flattened cells, which is derived from the epidermal stratum, and an outer or deeper layer of columnar cells, which represents the original endodermal layer.

The study of the development of the pharyngeal teeth shows that these teeth develop according to the typical vertebrate method, that is by an invagination of the lowermost epithelial layer of the pharyngeal mucous membrane forming an inverted cup-shaped enamel-organ which invests a mesodermal papilla, the dentine-organ. Thus it seems quite conclusive that the enamel-organs of the pharyngeal teeth of the carp are derived from the pharyngeal endoderm, since the lowermost epithelial layer of the pharyngeal mucous membrane has been shown to be the original endodermal layer of the primordial foregut.

The results of this study not only present evidence that the deeper columnar endodermal cells of the pharyngeal mucous membrane are the real formative elements in the formation of

the enamel-organs, but, also show that the inner flattened ectodermal cells do not appear to take part in the process. Suppose, however, that in the absence of any evidence to the contrary, the flattened ectodermal epithelium does invaginate along with the endodermal epithelium to form the enamel-organ. In such an event the ectoderm still could not be considered as contributing to the formation of the teeth, since it has been well established by investigators that the lowermost layer of the epithelium forms the enamel-organs, and, that the enamel, when present, is formed from the inner cylindrical cells of this organ.

The question may be suggested as to the probable influence of the ectoderm on the endoderm in initiating the formation of the enamel-organs. If the ectodermal cells in the pharynx influence the endodermal cells in this process, how can we account for the presence of tooth-like structures in the œsophagus of certain fishes and snakes, since they lie beyond the limits of the invaginated ectoderm? The conclusions arrived at in this paper are that endoderm possesses the capacity per se to form the enamel-organs of the pharyngeal teeth.

The question also arises as to whether the pharyngeal teeth of the carp are homologous with the typical vertebrate teeth. Obviously the answer depends upon the exact meaning of the term homology. If homologous structures are to be considered as those which have the same germ-layer origin then the answer is in the negative, since it has been shown in the present paper that the enamel-organs of the pharyngeal teeth of the carp are derived from endoderm, whereas, in the higher vertebrates they are formed from ectoderm. As the opponents of the doctrine of the specificity of the germ layers have repeatedly asserted, similarity does not necessarily prove that structures originate from the same germ layer. On the other hand, the pharyngeal teeth may be considered similar to the teeth of higher vertebrates, since they answer to the description and definition of a tooth as defined by Waldeyer ('72, p. 321) "The anatomical model of a vertebrate animal is a large papilla of the mouth or of the pharyngeal mucous membrane, which, in consequence of chemical and histological conversion of its constituents, has acquired a remarkable degree of hardness."

Summary.

1. The epidermal stratum becomes differentiated by 10 hours after fertilization.

2. The primitive hypoblast arises 13 hours after fertilization by a proliferation from the mass of cells at the posterior middle point of the blastoderm.

3. By 19 hours after fertilization the anterior margin of the primitive hypoblast has extended anteriorly until it comes into contact with the ectoderm ventral and anterior to the future head-region.

4. Differentiation of the endoderm occurs by a process of flattening and later separation from the overlying primitive hypoblast. The remaining portions of the latter give rise to the notochord in the middle line and to the mesoderm on each side of this.

5. The endoderm is completely established as a connected unicellular layer by 23 hours after fertilization. Its anterior extremity comes into contact with the ectoderm anterior and ventral to the future fore-brain area. At this stage the endodermal cells in the region of the pharynx have assumed a columnar shape, whereas, in the extreme anterior portion of the primordium of the foregut they are flattened.

6. By 30 hours after fertilization the single endodermal layer, which can be recognized by means of the columnar shape of its cells, begins to rise up on either side to form lateral, obliquely directed folds in the region of the pharynx. These folds represent the pharyngeal folds which later contribute to the formation of the gill-slits.

7. The further course of development of these folds shows that their apices extend laterally and dorsally until they come into contact with the nervous layer of the ectoderm. The latter responds by sending inward a wedge-shaped proliferation into the apices of the folds. This results in the formation of continuous folds, made up laterally of ectoderm and medially of endoderm, the boundary between the two germ layers being indistinct.

8. Subsequent stages show that cleft-like lumina appear in these folds, beginning laterally and extending medially. In the meantime the epidermal stratum migrates inward by way of these lumina to the solid depressed foregut. The pharyngeal

clefts thus come to be lined with an inner layer of flattened cells from the epidermal stratum and a deeper layer of columnar cells, the original endodermal layer.

9. Simultaneous with the formation of the gill-slits the foregut closes ventrally. This is brought about by the base of each pharyngeal fold growing medially and fusing with its fellow of the opposite side. The dorsal and ventral rows of cells thus formed are at first firmly pressed against each other without any evidence of a lumen between them.

10. Later stages show that scattered lumina appear between these two layers of cells and that these unite eventually thus establishing the lumen of the foregut.

11. With the appearance of a lumen in the foregut, the endoderm assumes the same structure as in the lumina of the pharyngeal clefts, that is, its lining then consists of an inner layer of flattened cells and an outer or deeper layer of columnar cells.

12. Observations on the development of the mouth present evidence to support the views of Dohrn and Ryder that the mouth develops similarly to the gill-slits. The mouth breaks through in the angle between the head and the anterior ectodermal wall of the yolk sac without any evidence of a stomodaeum. Furthermore, oral folds, which are similar in character to pharyngeal folds, extend diagonally forward and come into contact with the inner layer of the ectoderm posterior and ventral to the primordia of the eyes. Clefts form here similar to pharyngeal clefts and the epidermal stratum appears to migrate inward by way of these clefts in the same manner as in the pharyngeal clefts. The so-called oral clefts as well as the pharyngeal clefts appear to form by invaginations of the epidermal stratum thus establishing potential openings. In both instances the epidermal stratum migrates inward to the oro-pharyngeal cavity thus contributing to its inner lining. It is evident, therefore, that the inner lining of the oro-pharyngeal cavity is derived from ectoderm and that the deeper epithelial layer of the mucous membrane of this region represents the original endodermal layer.

13. Observations on the development of the pharyngeal teeth reveal that the enamel-organs are derived from the deeper coloumnar layer of the pharyngeal epithelium and are, therefore, endodermal in origin, since the deeper columnar

layer of the mucous membrane has been demonstrated to represent the original endodermal layer of the primordial foregut. Furthermore no evidence could be found of the inner flattened layer of cells contributing to the formation of the enamel-organs. The conclusion arrived at is that the enamel-organs of the pharyngeal teeth of the carp are, therefore, endodermal in origin.

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EXPLANATION OF PLATES.

PLATES I AND II.

These Figures were made with the aid of a Spencer drawing apparatus. Magnification × 300.

Figs 1 to 4. Sagittal sections through the blastoderm 10, 12, 13 and 19 hours, respectively, after fertilization.

Fig. 5. Transverse section through the blastoderm 21 hours after fertilization.

Fig. 6. Midsagittal section through an embryo 23 hours after fertilization.

Figs. 7 to 12. Transverse sections through the pharynx 30, 32, 35, 36, 39 and 56 hours, respectively, after fertilization.

Fig. 13. Sagittal section cut far laterally through the anterior region of an embryo 57 hours after fertilization.

Fig. 14. Transverse section through the pharynx of an embryo 78 hours after fertilization.

Fig. 15. Transverse section through the oral end of the foregut 27 hours after fertilization.

Fig. 16. Sagittal section cut far laterally through the anterior region of an embryo 59 hours after fertilization.

Plate III.

Fig. 17. Sagittal section cut far laterally through the pharyngeal region of the same embryo as in Fig. 13. × 900.

Fig. 18. Sagittal section through the anterior region of an embryo 80 hours after fertilization. × 100.

Fig. 19. Mid-sagittal section through an embryo 79 hours after fertilization. × 100.

Fig. 20. Sagittal section cut far laterally through the same embryo as in Fig. 19. × 100.

Fig. 21. Transverse section through the anterior end of the same embryo as in Figure 14. × 100.

Fig. 22. Photograph of the inferior pharyngeal bones of the last branchial arch, showing the pharyngeal teeth of an adult carp. × 2.

Plate IV.

Fig. 23. Sagittal section through the pharyngeal region of a larva 4 hours after hatching, showing the formation of an enamel-organ. × 900.

Fig. 24. Sagittal section through the pharyngeal region of a larva 18 hours after hatching, showing the further development of the tooth-germ. × 900.

Fig. 25. Section through the tooth-germ of a larva 25 hours after hatching. × 900.

Fig. 26. Section through a tooth-germ of a larva 44 hours after hatching. The small tip, E. t., appears to be a separate enamel tip. However, this is not certain, hence the interrogation point. × 1220.

ABBREVIATIONS.

A. m.—anterior mass of mesoderm.
A. p.—anterior pole of blastoderm.
B.—blastoderm.
Br.—brain.
D.—Dentine.
E.—eye.
Ec.—ectoderm.
En.—endoderm.
E. o.—enamel-organ.
E. o.′—inner layer of enamel-organ.
E. o.″—outer layer of enamel-organ.
E. p.—proliferating ectodermal plug.
E. s.—epidermal stratum.
E. t.—enamel tip (?).
F. g.—foregut.
G. a.—gill-arch.
G. s.—gill-slit.
H. a.—hyoid arch.
H. e.—head of future embryo.
H. m.—hyomandibular arch.
Me.—mesoderm.
M. p.—mesodermal papilla (dentine-organ).
N. l.—nervous or inner layer of ectoderm.
No.—notochord.
O. c.—oral-cleft.
O. f.—oral fold.
O. p.—oral plate.
O. v.—otic vesicle.
P.′—periblast.
P.—pharynx.
P. a.—pharyngeal arch.
P f.—pharyngeal fold.
P. h.—primitive hypoblast.
P. p.—posterior pole of blastoderm.
P. t.—pharyngeal tooth.
4V.—4th ventricle.
Y.—yolk.
Y. p.—yolk plug.

PLATE I.

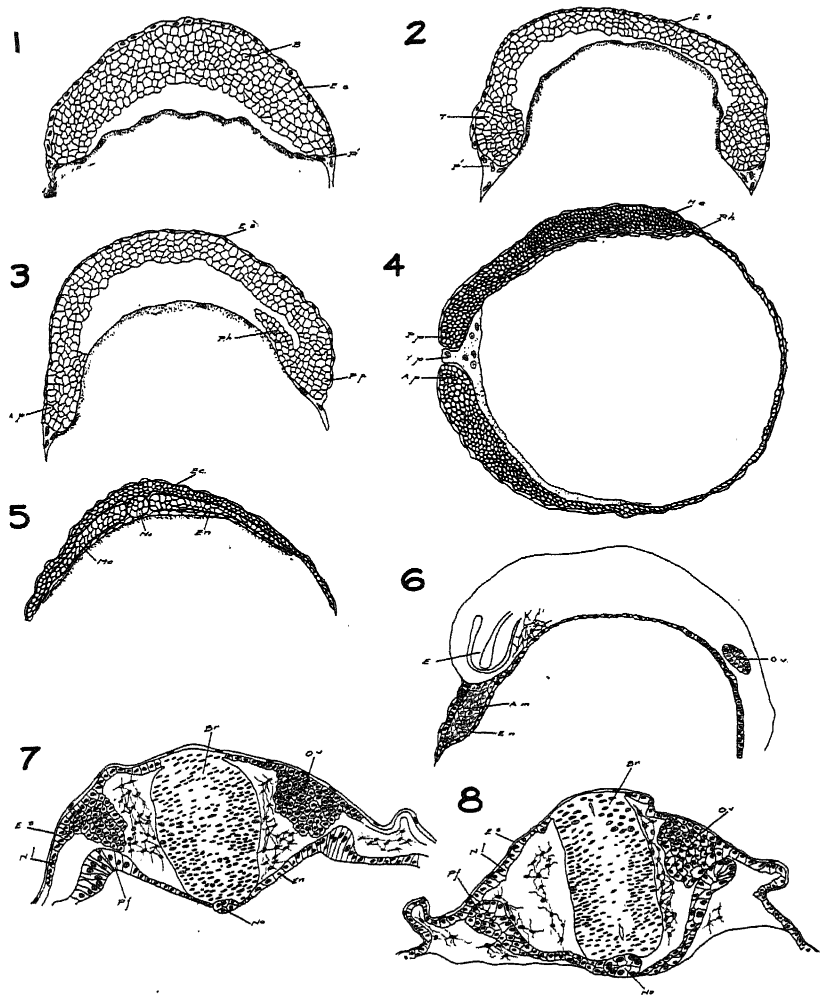


PLATE II.

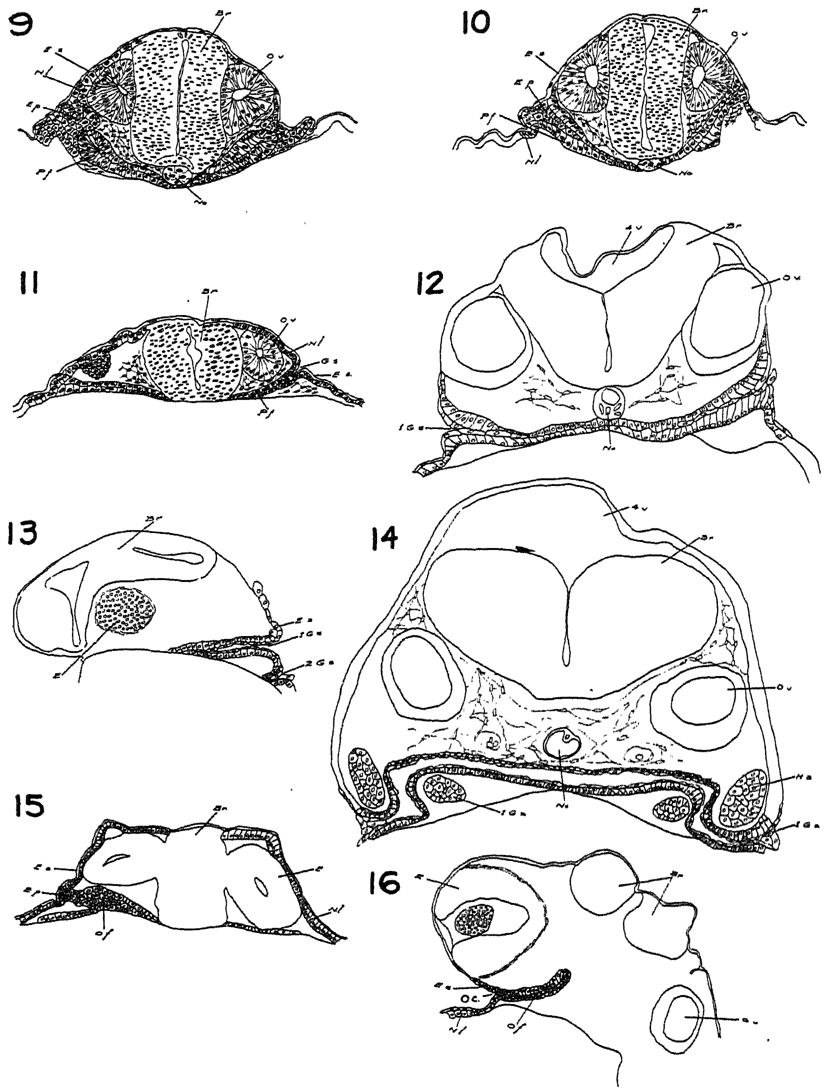
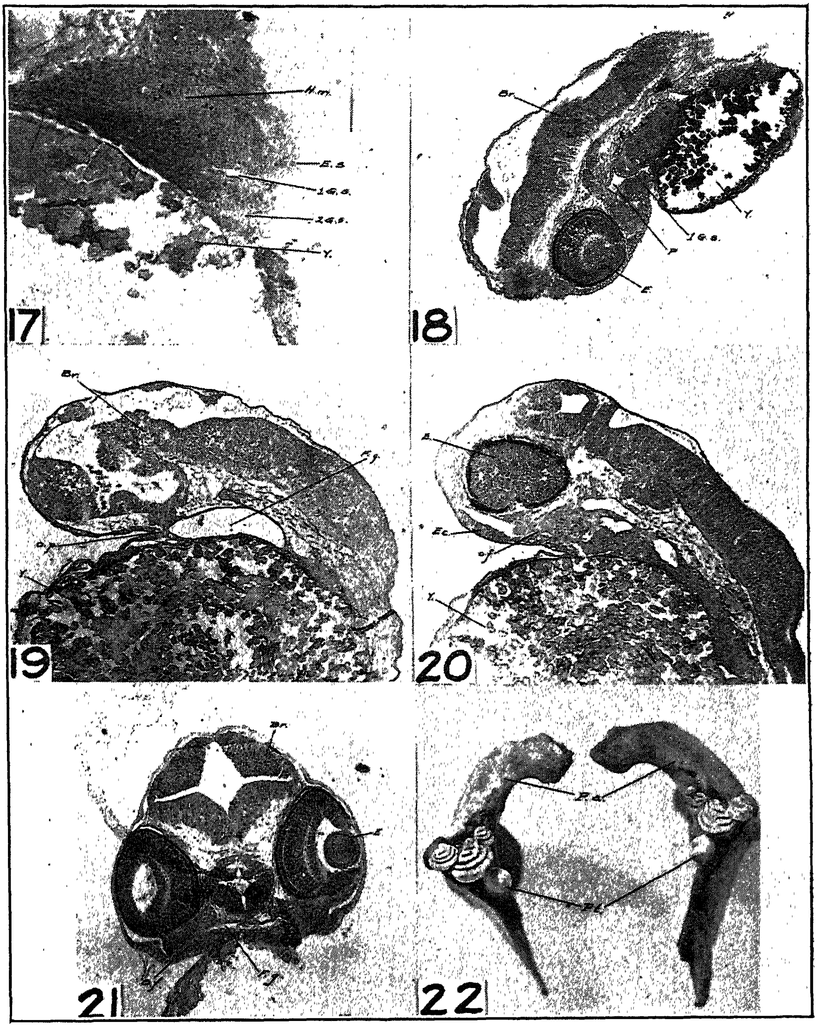
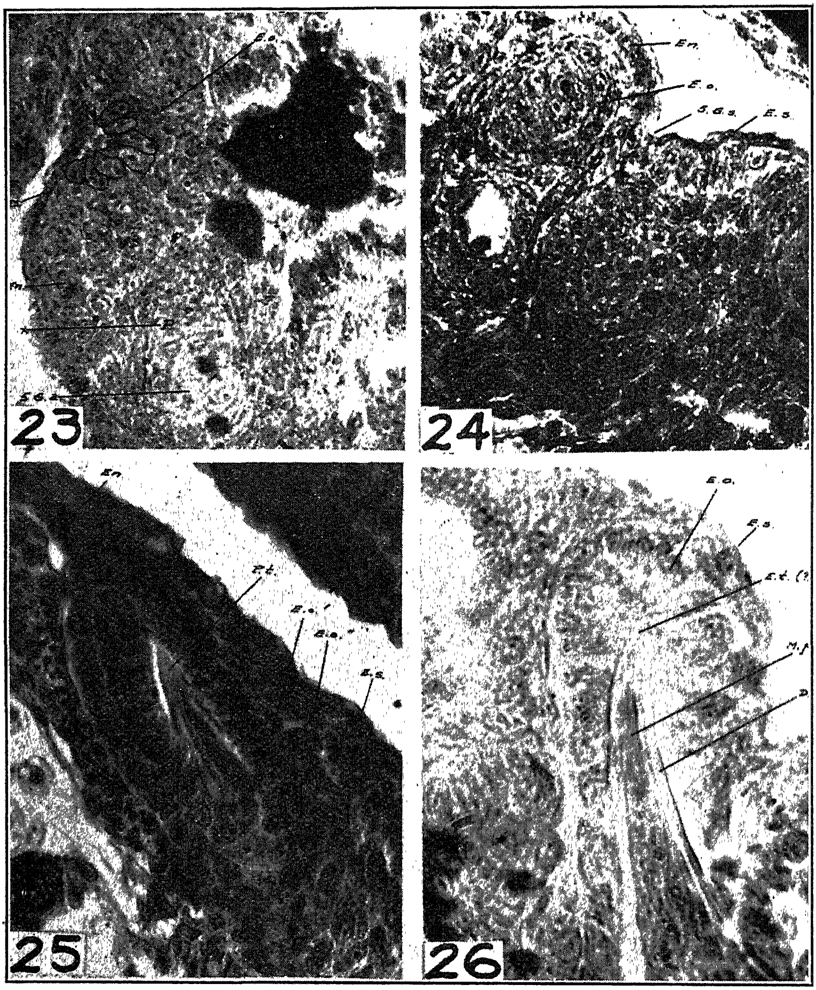


PLATE III.





SUGGESTED EQUATIONS FOR THE PHOTOSYNTHETIC REACTION.

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The recent monograph by Spoehr* gives a very complete summary of the work on photosynthesis. The importance of the process can hardly be overestimated, and the combined researches that have been carried on by botanists, biochemists, and plant physiologists have resulted in a large amount of data regarding the qualitative and quantitative aspects of the photosynthetic reaction. In the light of these results nearly all of the equations suggested to explain the reaction to students of botany are open to some very serious objections. The one that most frequently appears in text-books is the following:

$6H_2O + 6CO_2 +$ light energy acting on chlorophyll $\longrightarrow$
$C_6H_{12}O_6$ (glucose) $+ 6O_2$.

This equation avoids all intermediate steps by not mentioning them. An attempt is made in this paper to call attention to two simple equations which make use of definitely known substances common to plants in which photosynthesis takes place, and which seem to fit the known facts far better than the abbreviated equation above. Nearly all of the previous explanations have postulated intermediate products such as formaldehyde, glycollic aldehyde, carbon monoxide, and various peroxides, which are either unknown in plants or are found in such minute quantities as to make their significance questionable. It is definitely known, however, that photosynthesis does not take place in plants in the absence of chlorophyll, of which two kinds have been isolated by Willstätter and Stoll, who termed them Chlorophyll "a" and Chlorophyll "b." These two kinds of chlorophyll exist in the proportions of 2.58–2.75:1. During photosynthesis it is found that the total quantity of chlorophyll remains the same.

It is also definitely known that the ratio between the amount of carbon dioxide absorbed and the amount of oxygen evolved is approximately unity, and that water is necessary for the reaction. All of the observers have been impressed

*Spoehr, H. A. Photosynthesis. Chemical Catalog Co. (1926).

by the fact that vegetable tissues are capable of absorbing carbon dioxide in quantities considerably above that accounted for by the solubility of the gas in the water of the tissues. Willstätter and Stoll observed a decided absorption of carbon dioxide by leaves that had been dried and powdered and had subsequently been allowed to absorb water. Under these conditions, in the presence of sunlight, oxygen is evolved. However, if the leaves are first treated with ether and dried, oxygen is not liberated.

There is much in favor of the view, variously expressed by Willstätter and Stoll, Warburg, and others, that one of the steps in photosynthesis is not a splitting of CO_2 under the influence of light, but that the CO_2 undergoes a primary change through absorption by some constituent of the leaf.

Dixon and Ball have suggested the following formulæ to show the absorption of CO_2 by chlorophyll:

$C_{55}H_{72}O_5N_4Mg + CO_2 \rightarrow C_{55}H_{70}O_6N_4Mg + CH_2O$
(Chlorophyll "a" + Carbon dioxide → Chlorophyll "b" + formaldehyde)
$C_{55}H_{70}O_6N_4Mg + H_2O \rightarrow C_{55}H_{72}O_5N_4Mg + O_2$
(Chlorophyll "b" + water → Chlorophyll "a" + oxygen).

They assume, of course, as do all adherents of the so-called "formaldehyde theory," that formaldehyde is polymerized into a hexose sugar, such as glucose.

Maquenne evidently believes that in the colloidal state three molecules of chlorophyll are linked through secondary valencies of the single magnesium atom in each molecule. He assumes the final formation of a compound containing a chain of carbon atoms, for instance glyceric aldehyde or dioxyacetone, instead of formaldehyde. Spoehr suggested that in order to conceive of the direct formation of a hexose sugar it "suffices to admit the possibility of six chlorophyll molecules which absorb six molecules of carbonic acid."

Many of the investigators in this field are agreed that the photosynthetic process is composed of two reactions, one a chemical reaction with a temperature coefficient of about 2, and the other a photo-chemical reaction with a low temperature coefficient. The two following equations are suggested as a better representation of the probable behavior of chlorophyll in the process of photosynthesis:

(1) $6C_{55}H_{70}O_6N_4Mg + 6H_2O \rightarrow 6C_{55}H_{72}O_5N_4Mg + 6O_2$
(Chlorophyll "b" + water → Chlorophyll "a" + oxygen)
(2) $6C_{55}H_{72}O_5N_4Mg + 6CO_2 \rightarrow 6C_{55}H_{70}O_6N_4Mg + C_6H_{12}O_6$
(Chlorophyll "a" + carbon dioxide → Chlorophyll "b" + glucose).

PRINCIPLES OF PLANT TAXONOMY, VI.*

JOHN H. SCHAFFNER,
Ohio State University.

In the earlier papers of this series, the fact was developed that there are six, great, progressive transitions in the plant kingdom which delimit the seven fundamental stages or subkingdoms. These subkingdoms are of the greatest convenience in establishing natural classes, since it becomes much easier to segregate groups on a natural basis if the organisms to be classified are known to come within similar limits. We can then look for truly segregative characters within the limits indicated by the several transitions.

PROGRESSIVE MOVEMENTS AND STAGES WITHIN THE SUBKINGDOMS AND CLASSES.

The fifth paper of the series discussed in a general way the progressive evolutionary movements which are the basis of the taxonomic orthogenetic series. The most important of these progressive movements within the subkingdom will now be considered more definitely in relation to their importance in classification, since no proper arrangements can be made until such series are clearly understood. A given movement may affect practically all the classes and subclasses of a subkingdom or only a part of them. These subordinate series are of especial importance when one comes to the task of segregating orders and families within the class. For it frequently happens that the same progressive movement will appear in two groups long after they have become distinct through the acquisition of some segregative character. Among such movements may be mentioned the origin of heterogamy in several independent lower groups and the independent origin of the flower in a considerable number of higher groups. Other important examples are the development of unisexuality, and of moneciousness and dieciousness, which are attained in a multitude of lines with the most diverse morphological and physiological characters.

* Papers from the Department of Botany, The Ohio State University, No. 224.

PROTOPHYTA. The progressions in the protophytes are from the unicellular to the multicellular condition and also from the undifferentiated colonial condition of the cells to the differentiated condition. The filamentous forms show both ends differentiated alike in the lower levels while in the higher there is a distinct development of base and apex. If the Glaucocysteæ really belong to the blue-green algæ, they show a very decided advancement in the development of definite chromatophores and a highly organized nucleus with a nuclear membrane.

NEMATOPHYTA. In the evolution of the vegetative body the following progressive strata are to be recognized: (1). Unicellular organisms; (2). Colonial organisms including simple filaments with undifferentiated tips; (3). Simple filaments with differentiated base and apex; (4). Branched filaments with differentiated base and apex and sometimes intermediate cells; (5). Solid aggregates with differentiated base and tip, usually showing a juvenile filamentous phase. In the true fungi a number of distinctly progressive developments of the mycelium are in evidence. The lower mycelia are branched systems with some differentiation; higher up in the scale, mostly in connection with the reproductive process, highly complex fruiting bodies are developed in which mycelial differentiations are accomplished comparable to the complex tissue systems of the algæ and higher plants, whose bodies represent true solid aggregates.

In the reproductive systems the stages of sexual evolution are quite prominent; first, there is the progression from isogamous to moderately heterogamous conditions and then to the extremely heterogamous gametes and differentiated gametangia; second, the transition from plants which show no sexual states beyond the gametangia to forms with well-developed secondary sexual states and dimorphisms in the vegetative tissues beyond the gametangia; and third, the highest condition in which the secondary sexual state, either male or female, is in evidence throughout the entire gametophyte.

BRYOPHYTA. The sporophyte shows a definite series of distinct advances. In the first and lowest stage the entire sporophyte is a sporangium and the interior of the sporangium is completely sporogenous. The second stage represents a sterilization of the lower part and a differentiation into foot and

stalk. At the same time sterile cells appear in the sporangium. This is the first step in the shifting of the reproductive process from the central axis to a lateral appendage. In the higher bryophytes the central part of the sporangium becomes completely vegetative, developing a central columella, as in most of the mosses and in the hornworts. A fourth definite organ also appears, the hypophysis, with true stomata. The hypophysis and photosynthetic tissues around the sporangium with the stomata are the fore-runners of a leaf, and bryophyte sporophytes which have these structures are to be regarded as the highest in the scale. There is also the development of a central strand of tissue which is a primordial vascular system. In the Anthocerotæ, the intercalation of a growing zone between the sporangium and the foot is a very decided progression and foreshaddows an indeterminate sporophyte system. This growing zone is, however, not the fore-runner of the terminal growing point of the higher plants. This was attained through the transfer of the spore-reproductive process entirely away from the stem to the lateral appendages or leaves, thus permitting the terminal bud to develop vegetatively for an indefinite period after reproduction is begun. The presence of the central columella, the basal growing zone, development of stomata, and other advanced conditions place the Anthocerotæ as a separate class far above the Hepaticæ.

The gametophyte of the bryophytes also shows marked progressive stages. In the Hepaticæ, the highest development is in the cylindrical stem with differentiated types of lateral and ventral scales. In the mosses there are several advances, the erect gametophore coming from the protonema is a culmination type while the branched creeping forms are to be regarded as the more primitive types, although there may be a progression in the branching system, especially seen in such forms as have a creeping rhizome-like stem with erect aerial branches.

Several distinct stages are also to be observed in the progression of sexual evolution. The lower are hermaphrodites, the higher are unisexual. The unisexual condition is attained independently in many lines. The hermaphrodites fall into an ascending series approaching the unisexual forms. This series is in general: 1, synoicous condition, 2, paroicous, 3, autoicous, 4, unisexual; with various intergrading conditions. The series represents the actual evolutionary advancement not only in these plants but also in the progression upwards through the

higher subkingdoms and the species and groups are always to be arranged in this sequence, other things being equal.

PTERIDOPHYTA HOMOSPORÆ. There are three well segregated phyla represented in this subkingdom. In general there are two stages in the advancement of the gametophyte. The lower species have hermaphroditic gametophytes which give way to unisexual individuals in the highest species of the series. These movements are usually in the same direction as the progressive movements in the sporophyte. Thus the highest ferns like the sensitive fern and ostrich fern have unisexual gametophytes and the same seems true also for Equisetum, in which extreme species, like *Equisetum arvense*, have unisexual gametophytes while more primitive species, like *Equisetum laevigatum*, have hermaphroditic gametophytes.

The sporophyte of the lycopods shows progressive stages from indeterminate growth in the reproductive system to a definite, determinate flower; from very little difference between the foliage leaves and sporophylls in the lower species to decided dimorphism in the higher; from no peduncle developed below the cone or inflorescence to a very prominent peduncular development; from one type of foliage leaf to a complex system; from a simple, uniform reaction of the stem buds to light and gravity to a complex reaction; from a very simple branching system to a complex branching system, developed both in the vegetative part and in the inflorescence.

EQUISETEÆ. The living Equiseta show several definite progressive stages; from perennial aerial stems to annual aerial stems, attained independently several times; from no special dimorphism between the sterile and fertile shoots to a very decided dimorphism in some lines; from no peduncle to a prominent peduncle; from a sporangium-bearing ring or calyx to a completely sterile calyx; from a green sporophyll to a non-green sporophyll and finally to a completely non-green fertile shoot; from the aerial development of the flower to the completely geophilous development of the flower. All these movements correspond to the progressive movements evolved in plants in the higher subkingdoms.

PHYLLOPTERIDÆ. The ferns show various detailed progressive movements. Among these, the evolution of the sporophyll is conspicuous and represents a definite character which

will show lower and higher levels. In general one can distinguish three phases: 1. Undifferentiated sporophylls, or such as show no very distinct dimorphism with the foliage leaf; 2. Sporophylls that are partially distinctly differentiated, either at the tip, at the base, or in the middle; 3. completely differentiated sporophylls showing a decided dimorphism with the foliage leaf as in *Onoclea sensibilis*, *Osmunda cinnamonea*, and *Lorinseria areolata*. The vascular system with open bundles, cylindrical cambium, and a central pith is associated with the more primitive general morphology and is for this and other reasons regarded as the more primitive condition in the Ptenophyta while the various types of concentric bundle systems are specializations from this. The open system was carried up through the gymnosperms and angiosperms, and at various points bundle systems with short-lived cambiums and closed bundles like these of the monocotyls were evolved. The indeterminate perennial types represent the primitive Pteridophyta and from those in various lines the progression leads up to biennials and annuals which are the culmination types in the evolution of length of life of the individual.

PTERIDOPHYTA HETEROSPORÆ. In the Selaginelleæ, those species with very slowly determinate cones represent the primitive condition while the quickly determinate cones represent the advanced type of floral development. As in the lycopods, the radially symmetrical spiral arrangement of the leaves is the primitive condition while the species which have more or less flattened stems with the leaves spreading into two ranks are more advanced. The species with solid stems are more primitive than those of the same series having the vascular bundles in hollow tubes.

Isoetes does not show any striking linear series, the species all having practically the same fundamental morphology, but the water-ferns indicate several progressive movements. The species which have creeping rhizomes are more primitive than those with floating bodies. The genera which have both megasporangia and microsporangia in the same sorus are more primitive than those which have monosporangiate sori. The quillworts and selaginellas with the entire leaf differentiated as a megasporophyll or a microsporophyll are to be regarded as more advanced in their sexual evolution than the water-ferns although they may be lower in some other respects.

GYMNOSPERMÆ. All living gymnosperms, except the two genera, Cycas and Ginkgo, have evolved the determinate reproductive axis or the flower. In Cycas the flower is really present, but is expressed only in the staminate plant under the influence of the secondary male state. The flower shows a general progressive movement in all lines to a more prompt and definite determination, thus producing a decreasing number of sporophylls. In the extreme condition the entire flower is reduced to one sporophyll. There is also a definite progressive movement in the greater dimorphism shown between sporophyll and foliage leaf. Among the living species there are none with normal bisporangiate flowers but such a condition is found in some fossil groups. The two main stages are, therefore: 1, moneciousness and 2, dieciousness. In the conifers at least the diecious condition has plainly come out of the monecious condition and the series should always be arranged in this order, wherever the two conditions appear in the same line. There are many subordinate progressive series in the various lines which show in the vegetative parts as well as in the reproductive systems. One such vegetative advance is shown, as in the two preceding subkingdoms, by the development of internodes. The lower stages are without internodal development; the higher have very prominent internodes. Another progression is shown in the complexity of the branching system. The movement in leaf arrangement is from alternate, spiral arrangements in the lower forms to opposite and whorled arrangements in the higher groups. In various lines the progression is from two cotyledons to numerous cotyledons, rarely to one by the suppression of the second member. There is also a progression in certain lines, especially of the Pinales, from simple embryos to multiple embryos from one egg.

ANGIOSPERMÆ. The stages in the progressive advancement of the angiosperm series are mostly definite and are often repeated independently a great number of times. The main movements are as follows: In the line of sex determination, the three progressive steps are, 1, bisporangiate flowers; 2, various degrees of moneciousness; 3, dieciousness. The third condition sometimes follows the second and sometimes originates directly from the first. In duration, the general movement is from trees to shrubs and lianas, to perennial herbs, to biennial and annual herbs. This movement is repeated in a great number

of independent lines. The inflorescence usually proceeds from single flowers at the end of leafy branches or in the leaf axils, to loose flower clusters of various kinds, to very compact clusters; and occasionally the reduction brings about single flowers again. The flower shows very definite progressive stages. 1. Just as in previous subkingdoms, the evolutionary movement brings out all gradations from numerous floral parts to single sporophylls. Only rarely are the parts multiplied for a special reason in the more advanced groups, as in cacti for example. 2. The lower forms are hypogynous, the higher epigynous. 3. The lowest flowers are apocarpous, the intermediate are syncarpous, commonly with as many cavities as developed carpels, while the highest are syncarpous and have unilocular ovularies whether they are hypogynous or epigynous. 4. The lowest flowers have distinct perianth segments, and the higher united segments; or there is a gradual loss until the apetalous, asepalous or, completely naked flowers are attained in various lines. 5. The andrecium also often shows progressions from completely distinct organs to various types of unions in the highest members of the series. 6. The symmetry is almost invariably from the spiral, actinomorphic condition to a monosymmetrical or zygomorphic condition, through the unequal determinate growth of the upper and lower parts of the flower bud. 7. In some lines also hypogynous and epigynous hypanthia appear, which show progressive developments, or in some cases a reduction series, since the hypanthium, along with all the floral structures, is finally involved in the inevitable evolutionary progression of the earlier and earlier determination of the floral axis. 8. In general, the primitive angiosperms are insect pollinated with no special adaptations to special conditions. This condition leads on to the specialized flowers which can only be successfully pollinated by special types of insect visitors; or to wind pollination; or to water pollination if the plants are moving down under the water in their evolutionary progression. Either the anemophilous type or the entomophilous may finally end in self-pollination or cleistogamy, or in various types of parthenogenetic developments. These specializations appear many times, independently, in unrelated groups.

The movements indicated above are correct criteria for the serial arrangement of larger and smaller groups after the proper phyletic segregations have been made.

PROPER ARRANGEMENT OF THE GROUPS IN SERIAL SEQUENCE

In general, the groups are to be taken in the order of their several evolutionary advancements as indicated by the totality of their important characters. If two lines are at about the same level at their bases but the one shows a much longer evolutionary progression than the other, the one that attains the highest level at the end is to be taken up last. Even if a group is a little more advanced at the base than its next nearest segregate, it is to be taken up first, if the second one shows a much higher level at the end. In this method of arrangement, the ends of the series will always show the culmination types. This is very desirable if one is to acquire a general knowledge of plants in relation to the advancing evolutionary movements. It is evident that when we are following out lines of development we can only acquire a clear comprehension of the process when the end of the pursuit actually brings us to the highest type attained in the series as a whole as well as in each subordinate series.

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REPORT OF THIRTY-NINTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

WILLIAM H. ALEXANDER,
Secretary

The Ohio Academy of Science met in its Thirty-ninth Annual Meeting under most fortuitous circumstances; on the charming campus of historic old Wittenberg, in the delightful city of Springfield, famous for its beautiful homes. The meetings were held on Friday and Saturday, April 26 and 27, 1929, under the presidency of Prof. James S. Hine. The Wittenberg authorities including President Tulloss, Dean Shatzer, and a most efficient local Committee headed by Dr. W. C. Beaver, left nothing undone for the comfort and pleasure of the visitors the result being that after two days filled with happy associations all came away feeling definitely enriched intellectually, with a larger outlook on life, and more deeply inspired to attempt greater things in the future.

The attendance was unusually good, the spirit of optimism never more general or more evident, the programs never more balanced or satisfying, nor the papers on the whole of greater excellence. All showed a high degree of forethought and wisdom on the part of the vice presidents.

The banquet on Friday evening was a real event. The "S.R.O." sign was hung out long before the feast began; it was said that at least 300 were seated at the banquet tables. The flowers were profuse and beautiful (thanks to the *Xi Chapter of Beta Beta Beta* Biological Fraternity!), the menu highly satisfying, the music delightful, the words of welcome on the part of President Tulloss of Wittenberg College and Superintendent Shelton of the Public Schools most gracious and very pleasing, the response by President Hine to the words of welcome appropriate and sincere, and the introductory

remarks by the toastmaster, Dr. S. R. Williams of Miami University always to the point and frequently full of wit and humor! What more could one ask in the way of a banquet!

Following the banquet and in the same hall, occurred the showing of the famous *Canti Film*, a moving picture demonstration of living cells in growing culture, secured for the occasion by Dr. Raymond C. Osborn, who was scheduled to make the introductory and explanatory remarks in connection with the demonstration but owing to a temporary physical weakness at the time asked Dr. J. Paul Visscher of Western Reserve University to "pinch hit" for him, which Doctor Visscher did in a most acceptable manner. The impressions made by the film and the explanatory remarks by Doctor Visscher were profound and unforgetable.

The general program of the meeting was as follows, viz:

FRIDAY, APRIL 26.

9:45 A. M.—Business meeting.

10:30 A. M.—Scientific lectures and papers in general session.

1:30 P. M.—Scientific lectures and papers in sectional meetings.

6:30 P. M.—Banquet, Shawnee Hotel. Greetings by President Tulloss of Wittenberg College and by Superintendent F. M. Shelton, Springfield Public Schools, with response by President Hine.

8:00 P. M.—Showing of the Canti Film, with introductory and explanatory remarks by Dr. J. Paul Visscher of Western Reserve University.

SATURDAY, APRIL 27.

9:00 A. M.—Adjourned business meeting.

10:00 A. M.—Presidential Address on "The Distribution of Ohio Mammals by President James S. Hine, Ohio State University, followed by the showing of a motion picture film depicting "The American Eagle in Action" by Dr. Francis H. Herrick of Western Reserve University, author of the film, (2,000 feet).

1:30 P. M.—Scientific lectures and papers in sectional meetings.

MINUTES OF THE BUSINESS AND GENERAL MEETINGS.

The business meetings of the Thirty-ninth Annual Meeting of the Ohio Academy of Science were held in the auditorium of the Chemistry-Psychology Building, Wittenberg College, Springfield, Ohio.

The first session was called to order by President Hine at 9:50 A. M., on Fiday, April 26, 1929, with about seventy-five members present.

The President announced the following committee appointments, viz:

Committee on Membership—Wm. C. Beaver, Wittenberg College; G. W. Conrey, Ohio Agricultural Experiment Station; and Ralph V. Bangham, College of Wooster.

Committee on Resolutions—F. C. Waite, Western Reserve University; Albert P. Mathews, University of Cincinnati; and S. R. Williams, Miami University.

Committee on Necrology—Frederick C. Blake, Ohio State University and August Foerste, Dayton High School.

Then followed the reading of the reports of the officers. The report of the Secretary was read, accepted and ordered filed. The Treasurer being absent from the State, asked the Secretary to read a brief, informal statement of the Academy finances to which Dr. E. N. Transeau and Mrs. Ethel M. Miller added a word of explanation, all tending to show that the Academy is on a very satisfactory financial basis at this time, there being a probable balance after all bills are paid of between four and five hundred dollars. The Treasurer promised a complete, detailed report immediately upon his return to the State, in time for inclusion in the Proceedings.

The next item of business was the election, by ballot, of an *Auditing Committee*. Dr. E. N. Transeau and Dr. F. H. Krecker were placed in nomination and the Secretary was directed to cast the unanimous ballot of the Academy for the nominees which was done and they were declared elected.

Then followed the reports of the standing committees, in the following order, viz:

(a) *The Executive Committee;* report read by the Secretary.

(b) *The Publications Committee:* the chairman, Prof. F. O. Grover, Oberlin College, was absent and no report was made.

(c) *The Trustees of the Research Fund:* the report was read by the chairman, Dr. Herbert Osborn, Ohio State University.

(d) *The Library Committee:* the report was presented by Mrs. Ethel M. Miller, an assistant librarian, Ohio State University, and a member of the Committee.

The President then called for the election by ballot of a *Nominating Committee* of six, one from each section. The fol-

lowing were placed in nomination, the nominations ordered closed and the Secretary instructed to cast the unanimous ballot of the Academy for the nominees, viz:

A. *Section of Zoology*—RALPH V. BANGHAM, College of Wooster.
B. *Section of Botany*—HUGH M. RAUP, Wittenberg College.
C. *Section of Geology*—PARIS B. STOCKDALE, Ohio State University.
D. *Section of Medical Sciences*—SHIRO TASHIRO, University of Cincinnati.
E. *Section of Psychology*—MARTIN L. REYMERT, Wittenberg College.
F. *Section of Physical Sciences*—E. O. WEAVER, Wittenberg College.

The hour having arrived at which the reading of scientific papers in a general session of the Academy was scheduled to begin, it was moved by the Secretary that the business session adjourn to meet again at 9:00 A. M. the following day, Saturday, April 27, 1929, which motion prevailed and the first business meeting was declared adjourned at 10:35 A. M.

The general session was called to order by the President at 10:40 A. M. and the following interesting papers were presented, viz:

1. Life Challenges Science, by DAVID DIETZ, Science Editor, Cleveland Press.
2. S. P. Hildreth: Pioneer Biologist of Ohio, by H. R. EGGLESTON, Marietta College.
3. Parasites of Commercial Fish of Lake Erie, by RALPH V. BANGHAM, College of Wooster.
4. The Application of X-rays to the Study of the Structure of Crystals, by FREDERICK C. BLAKE, Ohio State University.
5. Thermophilic (Heat-loving) Bacteria, Including Their Distribution, Methods of Isolation and Identification, by W. C. BEAVER, Wittenberg College.

Dr. F. C. Waite of Western Reserve University in discussing paper number two pointed out the fact that the great majority of the early scientists received their training in medical schools.

The first general session was adjourned at 12:10 P. M.

(Reference is made in the introductory portion of these proceedings to the evening banquet and program).

The second business meeting of the Academy was called to order by President Hine at 9:00 A. M. sharp, Saturday, April 27, 1929, with about one hundred members present.

The reading of the reports of standing committees was resumed and the report of the *Committee on State Parks and Conservation* was read by the chairman, Dr. Herbert Osborn, Ohio State University.

Then followed the reading of the reports of special committees in the following order, viz:

(a) The report of the *Committee on the Election of Fellows:* report read by the Secretary.

(b) The report of the *Nominating Committee:* report read by the chairman of the committee, Dr. R. V. Bangham, College of Wooster.

(c) *The Committee on Membership:* report read by the chairman of the committee, Dr. W. C. Beaver, Wittenberg College.

(d) *The Committee on Necrology:* the committee was not ready to make a full and satisfactory report owing to the shortness of the time and lack of sufficient data; it asked for and was given an extension of time, promising to have a complete report in the hands of the Secretary in ample time for publication in the proceedings. The Secretary read a list of those known to him as having departed this life and asked that if members knew of any others that the names be given to the committee.

(e) *The Auditing Committee:* Inasmuch as the Treasurer made no report, the only matters referred to this committee for consideration were the reports of the Trustees of the Research Fund and of the librarian, Mrs. Miller, on the sale of Academy publications. The committee therefore requested and was granted further time, when a complete audit can be made.

(f) *The Committee on Resolutions:* report read by the chairman, Dr. F. C. Waite, and may be found elsewhere in this report.

Unfinished business was now called for and the Secretary presented to the Academy the recommendations coming from the Executive Committee, viz:

1. That Mr. George T. Spahr be elected a Patron of the Ohio Academy of Science, because of the "important favors" he has bestowed upon the Academy. Upon motion duly made and seconded, the recommendation was heartily and unanimously approved by the Academy.

2. That a committee of three be appointed by the President to consider the advisability and the ways and means of establishing facilities for encouraging junior scientific effort in Ohio and report with recommendation at the next annual meeting of the Academy.

After some discussion by Prof. Geo. D. Hubbard, of Oberlin, and others, it was unanimously voted to approve the recommendation.

Under the head of new business, the President called upon Dr. Herbert Osborn, the official representative of the American Association for the Advancement of Science, to present whatever message or word he might have to offer concerning the relations now existing between the two organizations. Doctor Osborn said, in part:

In addition to bringing the greetings of the National Association, I feel that there are a few matters that might properly be mentioned concerning the relations of the two organizations.

Speaking for the Permanent Secretary, I wish to call attention to the desirability of our members becoming members of the Association and of all Association members living in Ohio becoming members of the Ohio Academy of Science and thus add strength to both organizations in their efforts to promote Science in the State. Why not invite those members of the Association in Ohio not now members of the Academy to attend our meetings and enjoy the privileges of membership in the Academy?

The Academy Conference recently organized with the hearty sanction of the Council of the A. A. A. S., and more or less under the leadership of our own secretary, composed as it is of one representative from each of the affiliated academies and three members from the Association-at-large, serves as an excellent clearing-house between the two organizations and ought to afford an excellent means of cooperation and interchange of helpful ideas and suggestions among the state academies, possibly leading to joint meetings of neighboring state academies. The possibilities are great and the Association is very anxious to encourage and help the Conference in every way possible.

Our members are and should be, of course, interested in the fact that the Association is to meet in Cleveland in 1930 and will certainly want to do everything they can to assist the local committee in its plans for that meeting. Also, it is hoped there will be a large delegation from Ohio at the Des Moines meeting next December. Begin to make your plans now.

It is impossible, of course, in a moment of time to point out the many and material advantages of the affiliation between our Academy and the Association but no doubt the many ways in which the two may be of mutual service to each other will occur to you.

The President then called upon Prof. Eddy, as the representative of the South Carolina Academy, for remarks, but he was not present at the moment.

The Secretary reminded the Academy that the Kentucky Academy of Science was in annual session at this time at Berea, Kentucky, and suggested the sending of greetings. Upon motion the Secretary was instructed to send such greetings and, at the suggestion of Prof. J. Ernest Carman, the West Virginia Academy of Science, also in annual meeting, was included in the greetings.

The election of a delegate to the Council of the American Association for the Advancement of Science was brought up by the Secretary and upon motion duly passed was referred to the Executive Committee with power.

The selection of the time and place of the next annual meeting was also referred by unanimous vote to the Executive Committee with power.

Dr. E. N. Transeau, of Ohio State University, then offered the following motion, which was seconded by several, viz:

That a committee of six members, one from each of the six sections, be appointed by the President to look into the matter of a more adequate publication of the proceedings of the Academy, and of the Academy's relation to the Ohio Journal of Science, and report with recommendation at the next annual meeting of the Academy.

The motion provoked considerable and at times rather animated discussion by several members and when finally put to a vote was unanimously carried.

At 10:00 A. M., the business meeting was adjourned *sine die* and at 10:15 A. M. a general session of the Academy was called to order by President-elect F. C. Waite, who in a very happy way introduced President James S. Hine. President Hine then delivered the presidential address on the subject, "*The Distribution of Ohio Mammals.*" Following this address, Dr. Francis H. Herrick, of Western Reserve University, was introduced and presented in a very pleasing way a motion picture film, some 2,000 feet in length, made by himself and assistants, showing "*The American Eagle in Action.*"

REPORTS

Report of the Secretary

SPRINGFIELD, OHIO, April 26, 1929.

To the Ohio Academy of Science:

Fortunately and necessarily, the content of the secretary's report is a variable. He may include many or few of the details of his official duties during the year and he may say much or little about these details. To report all details would be deadly; to select wisely ought to be helpful and stimulating. The wise course at this time seems to be the omission of the great mass of details. Hence a short report.

In general, the details were very numerous, the work slightly irksome at times, but on the whole delightful. The members have been exceedingly courteous, considerate and appreciative; could not have been

more so; therefore, it is with the greatest pleasure that we again record our deepest gratitude for the continued loyal and sympathetic support of the membership. Every call upon the office received prompt, courteous and as far as we were able efficient consideration, our *one aim being service with courtesy.*

Of course the first task after the Cincinnati meeting was the compilation and publication of the proceedings of that, the 38th annual meeting of the Academy. The report of the 38th annual meeting contained three rather important innovations: first, the omission of the membership list; second, a list of current exchanges of the Academy deposited in the Ohio State Library, carefully compiled and ably edited by our efficient librarian, Mrs. Ethel M. Miller; and third, abstracts of 47 out of the 79 or so papers and addresses given at the meeting. This last mentioned innovation has received very favorable comment, so much so that it has been decided to repeat it this year. The secretary wishes here and now to congratulate the authors of these abstracts; many of them are obviously the work of experts. Note also that the report was much larger than usual. A very brief résumé of the Cincinnati meeting was also published in *Science* for May 25, 1928, (Vol. LXVII, No. 1743, page 538). The third Cincinnati meeting (38th Annual) was one of rare excellence in many ways, out of it grew a great store of fragrant, abiding memories carried away by those fortunate enough to enjoy the real Cincinnati hospitality, contributed to so generously by one whose sweet, quiet, modest spirit would doubtless be with us today but for an inexplicable, tragic element in human affairs that has forever robbed us of his benign presence and wise counsels! To be sure the appropriate committee will guide us in the proper action we should take to honor the memory of our late president, *Dr. Harris M. Benedict*, but the writer could not refrain, because of a year's delightful associations and helpful cooperation, from placing on record a sincere tribute to the sacred memory of a *friend.*

Immediately upon receipt of the news of the tragic death of Ex-president Benedict, the President, the Treasurer and the Secretary held a conference at which it was decided that the Academy should be officially represented at the funeral services in Cincinnati and the Treasurer, Dr. A. E. Waller, was selected and agreed to go, which he did. A few days later Dr. Waller received the following letter from Acting Dean M. J. Hubert of the College of Liberal Arts, viz:

CINCINNATI, OHIO, November 1, 1928.

DEAR PROFESSOR WALLER:

I should like you to know that we of the University of Cincinnati appreciate the visit that you paid us on the occasion of Professor Benedict's funeral. We were honored by the action of the Ohio Academy of Science in sending its representative to Cincinnati. Your thoughtfulness and sympathy have helped us to bear the burden of a very great loss.

Sincerely yours,

M. J. HUBERT,
Acting Dean of the College of Liberal Arts.

Early in June of last year, the section of geology, again under the leadership of Dr. A. C. Swinnerton, of Antioch College, assisted by

Prof. J. Earnest Carman of Ohio State University and Prof. August F. Foerste of Dayton High School, visited the outcrops of the Devonian in the Bellefontaine outlier and the outcrops of the Silurian in the Dayton-Springfield regions, some 38 persons representing 13 institutions joining in the party. Doctor Swinnerton's report is as follows, viz:

FIELD TRIP OF OHIO GEOLOGISTS.

By A. C. SWINNERTON, Antioch College.

The Annual Field Trip of the Geological Section of the Ohio Academy of Science was held in the vicinity of Dayton and Springfield, Ohio, on June 1, 2, and 3. Thirty-eight people representing thirteen institutions were in attendance.

J. Ernest Carman, of Ohio State University, and C. F. Moses, of Muskingum College, acted as guides on the first day of the excursion, when the party visited the outcrops of the Devonian in the Bellefontaine outlier.

On the second and third days August F. Foerste acted as guide, taking the party to outcrops of the Silurian in both the Springfield, Ohio, region and the area near the western boundary of the State.

Saturday evening at the Engineers' Club of Dayton, the group was addressed by Arthur E. Morgan, President of Antioch College, formerly chief engineer of the Miami Conservancy District, on the problems of flood prevention at Dayton.

A fifteen page mimeographed pocket field guide was published for the convenience of the members of the party. The booklet contained routes, sections to be visited, and a short account of the general relations of the formations.

The colleges and universities represented on the trip included: Antioch, Bowling Green, Kenyon, Miami, Muskingum, Ohio State, Ohio Wesleyan, Toledo and Wooster.

In March of this year the Secretary received a letter from Robert Underwood Johnson, Secretary of *The American Academy of Arts and Letters*, New York City, announcing that the Academy would celebrate the Twenty-fifth Anniversary of its founding on April 23 and 24, 1929, the purpose of said celebration being,

"to emphasize the significance of the Academy in advancing and preserving the ideals of letters and arts in the United States, as well as its close relations of association and interdependence with representatives of letters and the fine arts in lands other than our own. In particular we wish to emphasize the association and interdependence in the case of other academies."

The announcement closed with the hope that the Ohio Academy of Science would send a delegate to this celebration, or if no delegate, then a letter. After some correspondence with members of the Ohio Academy living in the vicinity of New York we finally secured Mr. E. E. Clayton, plant pathologist, now connected with the New York State Experiment Station at Riverhead, N. Y., to represent the Academy.

By permission of the Executive Committee, the Secretary again had the honor of representing the Academy on the Council of the A. A. A. S. at the New York meeting, last December, and acted as the chairman of the Academy Conference. We attended all the meetings of the Council except one or two, and several of the sectional meetings.

We have received, up to the present moment, 45 applications for membership which considerably more than overcomes the losses from deaths and resignations, so that we now have on the roll in the neighborhood of 575 members.

In closing, kindly permit the secretary to place on record his high appreciation of the fine spirit of cooperation shown by his fellow officers throughout the year and to congratulate the several vice-presidents on the excellence of the programs prepared for this meeting.

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secretary.*

Report of the Treasurer.

COLUMBUS, OHIO, March 20, 1929.

Mr. W. H. Alexander, Secretary of The Ohio Academy of Science:

DEAR MR. ALEXANDER:—On the eve of my departure for a Western trip I wish to turn over to you a tentative account of my treasurership.

The bank balance as of March 8, is $1,124.82. This compares with a balance of March 31, 1928, when the balance was $1,258.25. Checks are coming in every day and I have left instructions to have these cared for in my absence. Our expenditures will probably not be very different from last year, and I expect we will show about the same total surplus of three or four hundred dollars after our expenses have all been met.

Please present my regrets to the members of the Academy for not being with them.

Sincerely yours, A. E. WALLER.

Report of the Executive Committee.

SPRINGFIELD, OHIO, April 26, 1929.

To the Ohio Academy of Science:

The Executive Committee, upon the call of the President, held three meetings during the year; one on December 8, 1928, at the office of the Secretary; one on January 12, 1929, at the Faculty Club, Ohio State University; and the third, last evening, at the Shawnee Hotel, Springfield, Ohio.

At the first meeting the following items of business were transacted, viz:

1. Six applications for membership in the Academy, all in proper form and on file with the secretary, were favorably acted upon and recommended for election at the next annual meeting.
2. Berthé Couch Koch, a former member, was restored to membership in the Academy.
3. Wittenberg College, Springfield, Ohio, was selected as the place and April 26 and 27 as the time for the 1929 annual meeting of the Academy.
4. Voted to reimburse the treasurer to the amount of Ten Dollars ($10.00), for expenses incurred in the course of his official duties.

At the second meeting, it was voted:

1. That Dr. R. C. Osburn be requested to correspond with Doctor Kofoid relative to securing of the *Canti Film* for presentation at the April meeting of the Academy.

2. Several distinguished names were suggested as suitable persons to make the invitation address at the annual meeting and the secretary was instructed to correspond with said persons, in turn, and see if one of them could be secured for the annual meeting. (This was done but all had previous engagements.—SECRETARY).

3. The committee heartily approved of the suggestion that special invitations be sent to all living charter members of the Academy whose addresses are known, and urge them to attend the Springfield meeting as the banquet guests of the Academy and that some special reference be made to them at the banquet.

4. It was unanimously voted to recommend to the Academy the election of Mr. George T. Spahr as a *Patron of the Academy*.

At the third meeting, it was voted:

1. That the 45 applications for membership in the Academy now on file with the secretary, all in due form, be recommended for election by the Academy to full membership.

2. That Mr. H. C. Shetrone, a former member, be restored to full membership.

3. To recommend to the Academy the appointment of a committee of three by the President to consider the advisability and the ways and means of establishing facilities for encouraging junior scientific effort in Ohio, and report with recommendation at next annual meeting of the Academy.

(This last recommendation is the result of or is based upon a special report by the secretary to the Executive Committee to the effect that at least two state academies, namely, North Carolina and West Virginia, are now doing something along this line, the former by offering a prize "for the best essay upon a scientific subject written by a high school student" on some theme selected by the student, the composition not to exceed 2,500 words; the latter (West Virginia), has two plans, one a loan of $100.00 to a senior or graduate student who is in need of funds to pursue some research problem, the loan to be returned without interest at a fixed date; the other plan is a prize of $25.00 for the best essay of 2,000 to 3,000 words on some assigned topic, the work in all cases to be performed under definite rules governing the contest).

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secretary*.

Report of the Trustees of the Research Fund.

SPRINGFIELD, OHIO, April 26, 1929.

To the Ohio Academy of Science:

During the past year we have had no requests for grants to be paid within the year but requests have been made for allowances during the coming year.

The additions to the fund from interest receipts have amounted to $143.00; $48.00 on April 30, and $49.50, November 5, 1928, and $45.50 April 16, 1929.

Two hundred dollars ($200.00), have been placed in the interest-bearing fund and there is a checking balance of $62.91 which with

interest accruing in the next six moths will enable us to make small grants without drawing on the interent fund.

It may be noted that the entry of three interest payments results from the later date of the annual meeting this year. Also it may be noted that the research fund has grown from $1,362.91 in 1925 to $1,662.91 at present, and a total of $120 has been distributed in grants since the contributions from Mr. McMillin ceased.

SUMMARY.

Balance in checking account, April 7, 1928	$ 120.91
Receipt from interest as above	143.00
Total	$ 263.91
Invested in Certificate of Deposit	$ 200.00
Bank charge	1.00
Balance in checking account April 25, 1929	62.91
Total	$ 263.91

SUMMARY OF ASSETS, APRIL 25, 1929.

Bonds	$1,300.00
Certificates of Deposit	300.00
Balance in bank checking accounts	62.91
Total Assets	$1,662.91

(Signed) HERBERT OSBORN, *Chairman*,
EDWARD L. RICE,
GEO. D. HUBBARD.

Report of Mrs. Miller for the Ohio State University Library.

COLUMBUS, OHIO, April 23, 1929.

To the Ohio Academy of Science:

The work during the past year has been largely routine and hence there is not very much to be reported. Special Paper, No. 20, "Flora of the Oak Openings West of Toledo" by Prof. E. L. Moseley, was received soon after the annual meeting in 1928 and was mailed at once to 107 exchanges and to 12 botanical periodicals in this country and in Europe. In order to save the labor of addressing two sets of envelopes for the members of the Academy this Paper was not mailed to them until the Proceedings were received in July. The two publications were sent to 461 members and the Proceedings to 98 exchanges. Nine exchanges desire to receive only the Special Papers and a few have specified that they want only the botanical ones or the zoological ones. Hence it would seem as if the Special Paper for 1929-1930, No. 22, should represent some other section of the Academy besides the botanical section and should deal with geology, zoology or one of the other branches represented among the Academy members.

During this year seven new exchanges have been secured, two of them being State Academies, and three former exchanges have been resumed.

By agreement with the Business Manager of the Ohio Journal of Science, the Ohio Academy of Science librarian was relieved of the

task of caring for the sales of the individual numbers and volumes of the Journal. On July 31, 1928 a check for $157.75 was given to him for the sales of the Ohio Journal of Science from March, 1926 to the end of July, 1928, thus closing that account. On the same date a check for $146.25 was handed to the Treasurer of the Ohio Academy of Science for the sales of its publications from March, 1926 to the end of March, 1928.

The sales for this past year, April 4, 1928 to April 23, 1929, amount to $85.05, breaking all records for any single year. This sum will be given to the Treasurer after July 1, when the next dividend is due. With the addition of all the dividends, none of which have been withdrawn, the balance in the bank is now $103.61. The price list of the publications has been revised and will be off the press in a few days.

Respectfully submitted,

ETHEL M. MILLER

The following exchanges are additions and corrections to the list published in the Proceedings of the Ohio Academy of Science for 1928 by Mrs. Ethel M. Miller:

ARGENTINA.

La Plata. Obras completas y correspondencia cientifica de Florentino Ameghino.
Museo de La Plata (*).
Anales.
Revista.

BULGARIA.

Sofia. Société bulgare des sciences naturelles.
Travaux.

CANADA.

Ottawa. Department of agriculture.
Bulletins.
Circulars.
Pamphlets.
Reports.

CZECHOSLOVAKIA.

Prague. National museum.
Acta botanica bohemica.
Separates.
Charles university (*).
Fragmenta mycologica.
Mykologia.
Publications of the Faculty of sciences.
Studies from the Plant physiological laboratories.

GERMANY.

Berlin. Universität. K. Zoologisches museum.
Bericht.

MALAY STATES, FEDERATED.

Kuala Lumpur. Department of agriculture (*).
Bulletin.
Malayan agricultural journal.

POLAND.

Warsaw. Musée polonais d'histoire naturelle (*).
Annales zoologici.

UNITED STATES.

CALIFORNIA.

Berkeley. California. University (*).
Publications in entomology.

CONNECTICUT.

New Haven. State library.
Report.

ILLINOIS.

Springfield. Illinois state academy of science.
Transactions.

INDIANA.

Indianapolis. Indiana academy of science.
Proceedings.

IOWA.

Iowa City. Iowa. University (*).
Studies in natural history.

KANSAS.

Lawrence. Kansas academy of science.
Transactions.

OHIO.

Cincinnati. University. Institute of scientific research.
Papers.
Columbus. Ohio state archaeological and historical society.
Various duplicates.

WEST VIRGINIA.

Morgantown. West Virginia academy of science.
Proceedings.

Report of the Committee on State Parks and Conservation.

SPRINGFIELD, OHIO, April 26, 1929.

To the Ohio Academy of Science:

Probably the most important items to report at the present time are with regard to the Legislation providing for a State Commission of Conservation with the Department of Agriculture and the National Legislation providing for permanent bird refuges to be established in different states throughout the country.

The State Commission for Conservation should provide a permanent organization directly interested in conservation measures and naturally including such matters as are of special interest to the members of the Academy. It is hoped when this organization is completed that we may be able to secure action and determine policies with regard to the state owned tracts included in the state forests, parks, refuges and other tracts which include features making them of value for the preservation of native fauna and flora and obtain definite assignments of areas as sanctuaries or permanently guarded tracts to insure such preservation. Your committee will endeavor to maintain such contacts with the commission as to provide opportunity for suggestions from members of the Academy, and to secure attention to measures promoting the preservation of native life.

While the committee does not claim credit for the specific legislation passed, we believe that the public interest and demand for such action has been stimulated through its efforts and by the influence of individual members of the Academy.

The National Legislation referred to should result in the acquisition of desirable tracts within Ohio, and it is believed that the administration of such tracts will promote the preservation of our native fauna and flora as well as the migratory birds particularly considered in the legislation enacted.

Cooperation with officers of the U. S. Biological Survey may assist in securing attention to points which are of special interest to our members.

The growth of interest in conservation measures among public spirited people of the state is certainly a very encouraging feature and it is hoped that members of the Academy will continue their activities in this direction.

(Signed) HERBERT OSBORN, *Chairman.*
E. N. TRANSEAU,
E. LUCY BRAUN,
E. R. HAYHURST,
A. R. HARPER,
CONRAD ROTH.

Report of the Committee on the Election of Fellows.

SPRINGFIELD, OHIO, April 26, 1929.

To the Ohio Academy of Science:

A meeting of the Committee on the Election of Fellows was held at the Shawnee Hotel, Springfield, Ohio, on the evening of April 25, 1929, as per the call of the secretary. A quorum of the committee was present with President Hine in the chair. The following persons whose nominations in due form had been filed with the secretary were unanimously elected, viz:

KENNETH CHARLES COTTINGHAM, Ohio State University.
EDWARD SAFFORD JONES, University of Buffalo.
RAYMOND E. LAMBORN, Ohio State University.
WILLIAM JOHN MCCAUGHEY, Ohio State University.
LEONARD BLAINE NICE, Ohio State University.
MARTIN L. REYMERT, Wittenberg College.
WARREN POPPINO SPENCER, College of Wooster.
SHIRO TASHIRO, University of Cincinnati.
LLOYD WILLIAM TAYLOR, Oberlin College.
CHARLES VERNON THEIS, University of Cincinnati.
OTTO CHARLES VON SCHLICHTEN, University of Cincinnati.

Respectfully submitted,
WILLIAM H. ALEXANDER, *Secretary.*

Report of the Nominating Committee.

SPRINGFIELD, OHIO, April 27, 1929.

To the Ohio Academy of Science:

Your committee on nominations submits the following report, viz:

President—FREDERICK C. WAITE.
Vice-Presidents:
A. *Zoology*—DWIGHT M. DELONG.
B. *Botany*—LEWIS H. TIFFANY.
C. *Geology*—PARIS B. STOCKDALE.
D. *Medical Sciences*—LEONARD B. NICE.
E. *Psychology*—MARTIN L. REYMERT.
F. *Physical Sciences*—FREDERICK C. BLAKE.
Secretary—WILLIAM H. ALEXANDER.
Treasurer—A. E. WALLER.
Elective Members of the Executive Committee—C. G. SHATZER, E. N. TRANSEAU.
Trustee, Research Fund—HERBERT OSBORN.
Publications Committee—F. O. GROVER, F. C. BLAKE, E. L. MOSELEY.
Library Committee—F. O. GROVER.
Committee on State Parks and Conservation—J. E. CARMAN, E. L. WICKLIFF, ROSCOE W. FRANKS.

Respectfully submitted,
R. V. BANGHAM, *Chairman,*
E. O. WEAVER,
G. W. CONREY,
HUGH M. RAUP,

List of New Members.

The following is a list of the persons whose applications were approved and whose election was recommended by either the executive or the membership committee and who were unanimously elected to full membership in the Academy at the business session on April 27, 1929, viz:

ARN, ELMER R., Dayton Clinic, Dayton. (*Medical Sciences*).
ASHCRAFT, ALVA, Leesville. (*Zoology, Botany, Geology*).
ASHCRAFT, D. W., Ohio State University, Columbus. (*Anatomy and Physiology*).
BAHER, DONALD L., 141 N. Professor Street, Oberlin. (*Geology, Geography and Physical Sciences*).
BAWMAN, DONALD, Orrville. (*Zoology, Medical Sciences*).
BENARD, RALPH N., Rising Sun. (*Botany, Zoology, Chemistry*).
BERGER, F. L., 121 E. Lehr Ave., Ada. (*Physics*).
BIRD, PAUL H., 121 Washington St., Delaware. (*Geology*).
BRACHER, GEO. J., 723 Woodlawn, Springfield. (*Medical Sciences, Zoology; Psychology; Physical Sciences*).
BRAND, LULU S., 2603 University Court, Cincinnati. (*Zoology and Botany*).
BROWN, J. B., College of Medicine, O. S. U., Columbus. (*Physiological Chemistry*).
BROWN, VIRGINIA R., 4419 Belmar Ave., Toledo. (*Biology; Eugenics*).
CAMPBELL, LIDA MAY, 5 Huffman Ave., Dayton. (*Biology*).
CARPENTER, FLOYD F., Roosevelt High School, Dayton. (*Zoology*).
CECIL, RODNEY, Agricultural Experiment Station, Geneva, N. Y. (*Entomology*).
CHURCH, MARGARET B., Urbana University, Urbana. (*Biology, esp. Botany and Mycology*).
CLARK, A. B., Zoology Department, O. S. U., Columbus. (*Biology*).
CULBERTSON, JAMES T., 420 S. Grand Ave., Ft. Thomas, Ky. (*Biology*).
EVANS, ARTHUR THOMPSON, Miami University, Oxford. (*Botany*).
EWERS, LELA A., Zoology Department, O. S. U., Columbus. (*Zoology; Anatomy; Physiology*).
FARIES, RUTH, Wittenberg College, Springfield. (*Zoology; Medical Sciences*).
GLOCK, WALDO S., Ohio State University, Columbus. (*Geology; Ecology*).
GRAHAM, WM. A. P., Department of Geology, O. S. U., Columbus. (*Geology*).
HARTSON, L. D., Oberlin. (*Psychology*).
HICKS, LAWRENCE E., Botany Department, O. S. U., Columbus. (*Botany; Ornithology*).
HOWLAND, JOS. W., Plain City. (*Zoology; Entomology; Anatomy; Medical Sciences*).
ILLICK, J. T., 2109 Adelbert Road, Western Reserve Medical School, Cleveland. (*Zoology*).
JONES, DAVID T., Department of Biology, Marietta College, Marietta. (*Zoology; Mollusca*).
JONES, GEORGE T., 322 West College Street, Oberlin. (*Botany; Ecology*).
JONES, HAROLD C., 352 W. College St., Oberlin. (*Ecology; Botany; Ornithology; Zoology*).
KECK, H. E., Athens. (*Zoology*).
*KOCH, BERTHE COUCH, Department of Fine Arts, O. S. U., Columbus. (*Psychology*).
LINK, J. A., 14 North Limestone Street, Springfield. (*Medical Sciences*).
LUTZ, DAN N., 1408 Clifton Ave., Springfield. (*Zoology; Chemistry; Botany*).
MAYER, CHARLES C. B., 1605 Hunter Ave., Columbus. (*Entomology; Botany*).
MCCARTHY, E. F., Central States Forest Experiment Station, O. S. U., Columbus. (*Forestry, and all sciences bearing on it*).
MCCLOUD, MARGARET, 192 Orchard Lane, Columbus. (*Nature Study*).
MCCLOY, JAMES H., 37 West Broadway, Westerville. (*Physics*).
MCGREW, JOHN B., 109 East Ward Street, Springfield. (*Physics; Chemistry; Biology; Astronomy*).
MEIER, A. H., 619 North Bever Street, Wooster. (*Zoology*).
METZLER, SIGMUND, 14 Cambridge Avenue, Dayton. (*General Science*).
*MILLER, AUGUST E., Urbana, Ill. (*Entomology, esp. Arachnida*).
MILLER, JOHN, Department of Zoology, O. S. U., Columbus. (*Zoology*).

MONTGOMERY, BLANCHE, 884 North Nelson Rd., Columbus.
PETERSON, ALVAH, Ohio State University, Columbus. (*Entomology*).
SCHOFF, STUART L., 168 N. Professor Street, Oberlin. (*Geology*).
*SHETRONE, H. C., Ohio State Museum, O. S. U., Columbus. (*Archaeology*).
SHUMAN, HELEN WOODBURN, Salesville. (*Geology; Psychology*).
SLEESMAN, GEORGE B., South Union Street, Ada. (*Botany; Entomology*).
SMITH, ISABEL SEYMOUR, 145 Woodland Ave., Oberlin. (*Botany*).
SQUIRES, H. D., Orton Hall, O. S. U., Columbus. (*Geology*).
STANNARD, J. NEWELL, 44 West Vine Street, Oberlin. (*Geology; Chemistry*).
STEPHENSON, BERNICE, University of Cincinnati, Cincinnati. (*Botany*).
STEPHENSON, HESTER, University of Cincinnati, Cincinnati.
STUPKA, ARTHUR, 66 West Tenth Avenue, Columbus. (*Nature Study*).
SWINGLE, MARY, Box No. 32, Philo. (*Biology*).
THATCHER, R. W., 140 Elm Street, Oberlin. (*Geology*).
TRACY, BERNICE G., Department of Bacteriology, O. S. U., Columbus. (*Bacteriology; Botany—Medical*).
TUCKER, FORREST G., 99 South Cedar Street, Oberlin. (*Physics; Mathematics; Chemistry*).
TWITCHELL, GEO. B., 845 Dayton, Cincinnati. (*Geology; Medical Sciences*).
WEED, R. B., 805 Buckeye Bldg., Columbus. (*Geology*).
WINSTON, MATTIE, 2626 Euclid Avenue, Cincinnati. (*Geology*).
WOLFE, RICHARD E., 108 East Maple Street, Clyde. (*Biology; Physics; Chemistry*).
WOLFRAM, GEORGE, 1507 Michigan Avenue, Columbus. (*Ornithology; Nature Photography*).
WUESTNER, HERMAN, 3335 Cavanaugh Avenue, Cincinnati. (*Mineralogy*).
ZURCHER, ESTHER R., 360 West Ninth Avenue, Columbus. (*Biological Sciences*).

* Reinstatement.

List of Deceased Members.

BENEDICT, HARRIS M. (Ex-President)....Cincinnati
BERRY, FRED....Columbus
BOWNOCKER, JOHN A....Columbus
COLE, A. D....Columbus
McFADDEN, L. H. (Charter Member)....Dayton

Report of the Committee on Resolutions.

SPRINGFIELD, OHIO, April 27, 1929.

To the Ohio Academy of Science:

Resolved, That the Ohio Academy of Science expresses its appreciation to the authorities of Wittenberg College and to the Local Committee for the facilities, privileges and entertainment provided during the Thirty-ninth Annual Meeting of the Academy.

F. C. WAITE,
S. R. WILLIAMS,
A. P. MATHEWS,
Committee on Resolutions.

Postscript: In response to the above Resolution, President Tulloss, of Wittenberg College, wrote the Secretary as follows, viz.:

SPRINGFIELD, OHIO, May 7, 1929.

MY DEAR MR. ALEXANDER:

We greatly appreciate your kindly letter of April 27th. This has been brought to the attention of our Prudential Committee.

It was a genuine pleasure to all of us to entertain the Acodemy.

Cordially yours,
R. E. TULLOSS, *President.*

The Scientific Sections.

The following is a complete scientific program of the meeting, viz.:

PUBLIC LECTURES.

Address of Welcome.................................President R. E. Tulloss
Showing of the Canti Film with explanatory remarks....Dr. J. Paul Visscher
Presidential address on "The Distribution of Ohio Mammals,"
President James S. Hine
The American Eagle in Action by the use of a motion picture film,
Dr. Francis H. Herrick
The application of X-rays to the study of the structure of crystals, (44)
Frederick C. Blake

PAPERS.

(Numbers in parentheses after the title refer to abstracts).

1. Life challenges science..David Dietz
2. S. P. Hildreth: Pioneer Biologist of Ohio...................H. R. Eggleston
3. Parasites of commercial fish of Lake Erie (1)............Ralph V. Bangham
4. Thermophylic (Heat-loving) bacteria including their distribution, methods of isolation and identification.............................W. C. Beaver
5. Timing the codling moth spray for Ohio fruit growers (2).......T. H. Parks
6. Concerning Annelid "jaws" (3)............................S. R. Williams
7. Some uses of Mallory's triple connective tissue stain........A. W. Lindsey
8. On the systematic classification of the Naiades (4)..........John C. Lotze
9. Ectoparasitic Infusoria of bait minnows (5)...............Ralph V. Bangham
10. The explanation of electrotaxis in the earthworm............W. M. Barrows
11. Nesting of the herons in Ohio..........................Roscoe W. Franks
12. Observations on the micro-anatomy of a Parajulid diplopod.....R. A. Hefner
13. Methods used in culturing Copepoda and demonstration of some results obtained...Lela A. Ewers
14. Some conditions influencing the formation of the epiphragm of the snail, Walter C. McNelly
15. Some preliminary studies of Entomostraca of Lake Erie....J. Paul Visscher
16. Eggs from a virgin Polygyra thyroides (Say)..........Walter C. McNelly
17. A preliminary survey of the fishes of Clark County, Ohio......W. C. Beaver
18. The algal food of Pimephales promelas (Fathead minnows), (6), Elizabeth E. Coyle
19. Insect Collecting in Porto Rico..........................Herbert Osborn
20. Examples of orthogenetic evolutionary series in plants (7)..John H. Schaffner
21. Quantitative determination of yield as applied to forest plantations (8), L. F. Kellogg
22. Primary vegetation types of Indiana.....................Robert B. Gordon
23. Trypetheliaceae of North America.........................Joyce Hedrick
24. Surveys in the upper Mackenzie Basin, N. W. Canada.........Hugh M. Raup
25. The physiological action of ultra-violet rays upon plants, Herbert C. Beeskow
26. The genus Wolffia in Ohio....................................W. H. Camp
27. A so-called "Alkali Disease" of stock, due to plant poisoning, Arthur T. Evans
28. The difference in sex-expression produced by increasing and decreasing photoperiodic gradients (9)...........................John H. Schaffner
29. Structure of some carboniferous plants...................J. Hobart Hoskins
30. Water loss from leaves in various conditions (10).........Glenn W. Blaydes
31. The vegetation of the Wood Buffalo Park..................Hugh M. Raup
32. Dry car-bruise of apples..O. T. Wilson
33. The distribution of three Southern Pines in Ohio................W. H. Camp
34. Announcement of plans for the annual field trip (11)........C. H. Behre, Jr.
35. Some features of the surface deposits of Ottawa County, Ohio (12), G. W. Conrey

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43. A study of some Devonian coral genera (20)..............GRACE A. STEWART
44. A new interpretation concerning the Hillsboro sandstone, (21), J. E. CARMAN AND E. O. SCHILLHAHN
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50a. Some structural features in rocks induced by glacial movement (28), WALDO S. GLOCK
51. Marl balls of the Miami valley (29)...........................J. T. ROUSE
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53. Some methods of correlation based on heavy mineral concentrates (31), W. A. P. GRAHAM
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54a. Drainage modifications along the Blue Ridge (33).........FRANK J. WRIGHT
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56. *The asthenic goitre syndrome........W. F. LAUTERBACH AND FRANCIS MOLZ
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60. The effect of feeding varying amounts of fish oil on the composition of the depot fat of the white rat..................J. B. BROWN AND S. G. MORRIS
61. Rickets in rats...ALFRED T. SHOHL
62. The effect of raw and boiled yeast on the motility of excised rabbit intestine (34)............F. A. HITCHCOCK, J. B. BROWN, AND H. E. HAMLIN
63. Correlative activities of the digestive tract in the domestic fowl (35), D. W. ASHCRAFT
64. The position of histidine in the protein molecule............GARRET J. BOONE
65. The increase of toxicity of rattle snake venom by a blood-coagulant, W. M. BILLING
66. Adrenalin and muscular fatigue (36).........................R. J. SEYMOUR
67. Familial pernicious anemia............................STANLEY E. DORST
68. Sexual differences in the blood of mammals..........WARREN H. REINHART
69. The blood pressure of the common Wood-Chuck (37)......HOWARD E. HAMLIN
70. The function of the adrenal gland............................J. M. ROGOFF
71. Silicosis in Ohio industries...........................B. E. NEISWANDER
72. The role of iron in the oxidation of cysteine and its neutralization by cyanides...ELMER G. GERWE
73. A vitamin preparation in the treatment of diabetes (38)..........C. A. MILLS
74. Toxemias of pregnancy treated by magnesium sulphate and glucose, ANDREWS ROGERS
75. Reticulocytes, their origin and significance, C. L. SPOHR AND MISS ALICE BUSTIN

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* Owing to an oversight by the Vice-President of the Section, the authors of this paper were not informed that it had been placed on the program and so were not present to read it. It was read by title only.

76. Syphilitic myelitis following injection of arsphenamin, H. L. REINHART AND ERNEST SCOTT
77. Unusual Echinococcus Cyst....MISS MARGARET OLIVER AND ERNEST SCOTT
78. Why do circles appear elliptical when seen in the Stroboscope? (39), W. K. WILSON
79. General adaptive behavior of idiots and pre-school children (40), CECELIA GORSUCH
80. Orientation in the earthworm (41)............................A. R. LAUER
81. The psychogalvanic technique with children 11–17 years of age, H. A. COPELAND
82. The technical vocabulary of the beginning student in psychology, (42), HORACE B. ENGLISH
83. Student superstition and the study of psychology (43).......H. C. LEHMANN
84. Reports from the Ohio laboratories: Brief reports on investigations in progress: Informal.
85. The use of photo-electric cells for spectral line intensity measurements, A. F. DITTMER
86. The importance of crystal growth in colloid systems (45)......W. G. FRANCE
88. Formation and life of the metastable mercury atom (46).........M. L. POOL
89. A study of phenol disinfectants (47)..........................J. R. HARROD
90. A new C. T. R. Wilson cloud-expansion apparatus (48)....GORDON L. LOCHER
91. Free air-pressure maps as an aid in forecasting winds and weather conditions along airways (49)............................LLOYD D. VAUGHN
92. The return of the wandering water molecule (50)..........W. H. ALEXANDER
93. Motion of the ball on a bowling alley (51)....................L. W. TAYLOR
94. Adjustable wall mountings for galvanometers and similar instruments (52), B. J. SMYTH
95. Determination of e/m for the electron in the undergraduate laboratory (53), FORREST G. TUCKER
96. Some applications of megneto-striction including a precise method of measuring the velocity of sound in air (54)....................M. GRABAU

DEMONSTRATIONS AND EXHIBITS.

1. Ecological variations as shown by Unionidae of Lake Erie and rivers of Ohio..H. R. EGGLESTON
2. Preparations stained with Mallory's C. T. Stain. (Microscopes, preferably with mechanical stage, required)..........................A. W. LINDSEY
3. Demonstration for Paper No. 3, General Session: Charts and Photomicrographs, RALPH V. BANGHAM
4. About 70 specimens of the fishes of Clark County, Ohio..........W. C. BEAVER
5. Plants from the Mackenzie Basin..........HUGH M. RAUP AND LUCY C. RAUP
6. A new method of recording psychogalvanic responses...HERMAN A. COPELAND
7. Map showing the distribution of three pines (*P. virginiana*, *P. echinata*, *P. rigida*) in Ohio...W. H. CAMP

AUTHORS' ABSTRACTS

OF

Scientific Papers and Discussions at the Springfield Meeting, April 26 and 27, 1929.

All persons delivering addresses or presenting papers at the Springfield meeting were asked to prepare and submit abstracts of addresses and papers for publication in the Proceedings of the meeting. The following have been received by the Secretary in time for inclusion in this report. These are arranged by sections and numbered consecutively for convenience of reference.

A. THE SECTION OF ZOOLOGY.

Dr. Annette F. Braun, Cincinnati, Ohio, *Vice-President.*

1. *Parasites of Commercial Fish of Lake Erie.*—By Ralph V. Bangham, College of Wooster, Wooster Ohio.

This study was conducted for the Fish and Game Division of Ohio during the summer of 1928. Fish for study were obtained in the following ways: from experimental trap nets in the vicinity of Sandusky; from seine hauls at numbered stations along the Ohio shore to and including the Maumee Bay, along the Michigan shore of Lake Erie to the Detroit River; the vicinity of the Bass Islands; gill and pound nets of commercial fishermen along the Canadian shore and Ohio shore east of Peele Isle; from floating dead fish.

Five hundred fish from Lake Erie have been examined and the parasites identified. These fish belong to twenty-four species. Only the data from the fish of commercial importance are included in this paper.

A general discussion of the conditions with regard to disease and parasites is given. No correlation could be established between pollution and degree of infestation. In only a few cases were sufficient parasites found to cause serious damage to the host.

A study was made of the dead fish floating on the surface and on the shore line of Lake Erie during the latter part of July. The possible causes of this loss are discussed.

A brief summary of the parasites of the following species of commercial fish is given: whitefish (*Coregonus clupeiformis*); cisco (*Argyrosomus artedi*); sturgeon (*Acipenser rubicundus*); silver catfish (*Ictalurus punctatus*); common sucker (*Catostomus commersonii*); Carp (*Cyprinus carpio*); yellow pike (*Stizostedion vitreum*); blue pike (*Stizostedion glaucum*); sauger (*Stizostedion canadense griseum*); yellow perch (*Perca flavescens*); sheepshead (*Aplodinotus grunniens*).

2. *Timing the Codling Moth Sprays for Ohio Fruit Growers.*—By T. H. PARKS, Ohio State University, Columbus, Ohio.

The time for application of the first cover spray is determined by: (a) daily emergence of moths in cages and from tree trunks kept under observation and where protruding pupa cases are removed daily; (b) keeping record of 6 P. M. temperatures suitable for egg laying.

3. *Concerning Annelid "Jaws."*—By S. R. WILLIAMS, Miami University, Oxford, Ohio.

Many Annelids have chitinous projections in the pharynx which serve either for holding or for rasping.

In almost all cases there is an introvert—a section of the buccal region which when everted will expose these jaws.

There are two types of jaws:

1. Those which are directly on the course of the alimentary canal (*Nereis* etc.).

2. Those which lie in a ventral eversible pocket (*Leodice*, etc.).

If we consider the everted position of the introvert as primitive these jaws must have developed from the chaetal pockets of the inturned segment or segments. These pockets typically would be 4, (aquatic Oligochetes 4 clumps of setae, Earthworm 4 double rows of setae.

Nereis paired parapods each with notopodium aciculum and setae, neuropodium aciculum and setae).

Normally these would develop 4 jaws: two dorso-lateral, two ventrolateral.

If in a ventral pocket, a dorsal set the maxillae, a ventral set the mandibles.

All sorts of modifications, by omission or addition, from *Staurocephalus* with a dozen maxillae to the Syllids with one dorsal median stabbing jaw.

4. *On the Systematic Classification of the Naiades.*—By JOHN C. LOTZE, Miami University, Oxford, Ohio.

A review of the more recent advances made toward a systematic classification of the Naiades (pearly fresh water mussels) showing the importance of the anatomical structures of the soft parts of the specimens in classification. The paper attempts to show the finer anatomy of the gills, arrangement of the ova and embryos in the marsupium, and structures of the edge of the mantle, all characters which are important in this classification.

5. *Ectoparasitic Infusoria of Bait Minnows.*—By RALPH V. BANGHAM, College of Wooster, Wooster, Ohio.

This paper is the result of studies concerning the serious loss of minnows by certain bait dealers. The short survey was conducted during the latter part of August, 1928 for the Ohio Fish and Game Division.

The losses and distress to the fish were attributed by the dealers to be due to the city water, but such was not found to be the cause. The

minnows were usually quite noticeably affected within 36 hours after they were brought in. There was a silvery sheen over the heads of many of the fish and the tails were white and frayed. There were large white areas where the skin was off. There was an increased mucus secretion. The sick minnows at first kept near the bottom of the tank and when very weak came to the top and died.

The conditions noted were caused by a mixed infection of *Cyclochaete* sp., and of *Chilodon cyprini.* The former is the larger and more active, but was not nearly as numerous as the latter parasite. The fish that were most heavily infested with these parasites when first brought into the tanks from the streams were stone roller (*Campostoma anomalum*), and common sucker (*Catostomus commersonii*). Temperature and crowding affected the spread of these forms. Control measures are discussed.

Another ectoparasite, *Ichthyophthirius multifiliis*, which affects minnows as well as other fish especially in the early spring when the water is cooler, is discussed.

6. The Algal Food of Pimephales promelas (Fathead Minnow).—By ELIZABETH E. COYLE, College of Wooster, Wooster, Ohio.

In recent years increasing interest has been shown by icthyologists and those people concerned with fish culture regarding the food of our common fishes. The purpose of this paper is to describe the food of *Pimephales promelas* Rafinesque, the fathead minnow, giving special emphasis to the algal food, but also mentioning the animal forms and other materials found in the alimentary canal.

Pimephales promelas belongs to the mud-eating group of minnows. It feeds near the bottom taking in plant and animal food and organic remains along with large quantities of mud. Previous records tend to indicate that the fathead takes in more animal than plant food, but present observations show that animal food is proportionately less abundant than is the plant food. Of the animal forms observed, the Entomostraca were by far the most abundant. The other animal forms consisted of Rotifers, Nematoda, and the remains of a few small insects. Pieces of plant tissues were found rather frequently, but the algal material found in the alimentary canal is probably the only plant material which is used for food to any great extent. Two hundred three fish were examined and one hundred twenty-eight algal species and varieties were identified in the alimentary canals. It was found that the 128 species and varieties are distributed among the classes of algæ as follows: Myxophyceæ 34, Chlorophyceæ 63, Heterokonteæ 1, Euglenineæ 10, Peridinieæ 2, and Diatomeæ 18. *Pimephales promelas* does not appear to be nearly so much of an animal feeder as Kraatz has shown Pimephales notatus to be, neither is it so much of a plant feeder as is the gizzard shad which was studied by Tiffany in 1920.

B. THE SECTION OF BOTANY.

DR. E. LUCY BRAUN, University of Cincinnati, *Vice-President.*

7. *Examples of Orthogenetic Evolutionary Series in Plants.*—By JOHN H. SCHAFFNER, Ohio State University, Columbus, Ohio.

All ordinary evolutionary movements give rise to orthogenetic series. Eight examples of this nature are considered and illustrated. The first represents an increasing differentiation between the foliage leaf and carpellate bract of species of *Abies*, beginning with *A. venusta* and ending with *A. lasiocarpa.* The second illustrates the evolution of the spikelet and its awn in the genus *Stipa* by 11 species, reaching from *S. macounii* to *S. pennata.* The third is the orthogenetic development of the little "horn" in the stamen appendages or coronahoods in the Asclepiadaceæ, shown by 6 progressive examples. The fourth represents an orthogenetic series of 7 stages resulting in over-adaptation in the development of a parachute on the achene, as illustrated in various groups of the Cichoriaceæ, running from *Sonchus* through *Lactuca* to the dandelion and salsify. The fifth series represents, by 8 stages, the peculiar movement which results in a flat vegetative system as illustrated by passing through a progression beginning with *Manfreda* through *Hymenocallis*, Iris, etc., to *Sisyrinchium graminoides.* The sixth series shows a progressive movement through 6 grasses, beginning with the two or three bristles present at the base of the pair of spikelets of *Chaetochloa verticillata* and ending in the elaborated bur of *Cenchrus palmeri.* The seventh series shows, by 5 stages, how an "alabaster box" to hold the spikelets and grain evolved by a continuous orthogenetic movement from *Andropogon furcatus* to *Euchlaena mexicana.* The eighth series represents the movement, in 12 steps, in a series of plants belonging to the mint family, of the perfection of a brush mechanism from a stamen. Beginning with a species like *Agastache scrophulariaefolia* with normal stamens and anthers, three special movements, (1) separation of the two halves of the anther, (2) rapid increase in size of the structures involved, and (3) progressive sterilization of the one half of the anther through the orthogenetic development of zygomorphy, bring about the remarkable pollen brushes with lever handles as are present in such extreme species of *Salvia* as *S. patens.*

8. *Quantitative Determination of Yield as Applied to Forest Plantations.*—By L. F. KELLOGG, Assistant Silviculturist, Central States Experiment Station, Columbus, Ohio. (Introduced by E. F. McCarthy).

As a basis for the study there has been planted in the past in the Central States Region, an aggregate acreage estimated at 266,000 to 300,000 acres. Of this, about 14,000 acres is estimated for Ohio. The purposes of the study are two-fold: to secure data on the later success of plantations and to predict yield of planted species. Factors having special bearing on the volume of stands are site, quality, spacing, age, form, and injurious agencies.

The method of study involves (1) establishment and measurement of suitable sample plots, (2) computation of volume, (and the construction of volume tables) and (3) the statistical analysis of the data to correlate variables and secure curves of yield. The character of sample plots and data which are taken are discussed. A sample yield table is included to show the form and nature of data it contains.

A few slides illustrate forest plantations such as are studied and an exhibit contains instruments and forms used in sample plot work.

9. The Difference in Sex-Expression Produced by Increasing and Decreasing Photoperiodic Gradients.—By JOHN H. SCHAFFNER, Ohio State University, Columbus, Ohio.

Indian corn (*Zea mays*) was grown from successive plantings at the beginning and middle of the month from August 1 to April 15. It was found that although a deficiency in the length of daylight produces the same general effect, changing the tassel from maleness to partial or complete neutrality or to femaleness, yet when the corn was growing in a decreasing photoperiodic gradient, from a longer to a shorter day, the distribution of the various sexual tissues was different than when the photoperiodicity was increasing. Completely neutral tassels are produced only on a decreasing light schedule. No completely neutral tassels have appeared when the corn was growing in a lengthening photoperiodicity. Also, in the decreasing daylight of the autumn, femaleness develops only at the base of the tassel and its branches, the tips always being neutral with abortive spikelets, while on an increasing light schedule of the winter and early spring femaleness is sometimes expressed at the tips of the main axis and branches as well as at the base, with staminate spikelets between the two ends. There is sometimes also sporadic reversal on the tassel, the carpellate spikelets being distributed here and there among the staminate ones. These differences of expression in the decreasing and increasing photoperiodic gradients are to be explained with reference to the movements of the differentiation gradients in the inflorescence. In Indian corn, as in various other highly specialized plants the differentation does not follow the ontogenetic development of the axis and cell lineage, but the earliest flowers appear about the middle of the main axis of the inflorescence and its branches. From this point the blooming progresses in opposite directions toward the base of the apex. Thus it is evident that the upper part of the differentiation gradient of flower development goes hand in hand with the natural growth and determination gradient and the lower part moves in the opposite direction. Because of this, it follows that a changing photoperiodic gradient of the proper length of daylight to change the sexual states will result in different expressions in the tassel, depending on whether the light is increasing or decreasing.

10. Water Loss From Leaves.—By GLENN W. BLAYDES, Ohio State University, Columbus, Ohio.

Diurnal rates of water loss, as indicated by the standardized, cobalt chloride, hygrometric paper, have been obtained for 138 plants. This

group is made up of representatives of several associations; of the same species growing in several associations; comparisons of loss from leaves in different positions; comparisons of loss from young, mature and old leaves; comparisons of loss from a partial parasite (*Commandra*) and its host (*Vaccinium*), etc. In general, the maximum standard water loss is reached during the morning. Very young leaves, for those species tried, lose less water than mature leaves, and old leaves less than mature ones.

C. THE SECTION OF GEOLOGY.

DR. CHARLES H. BEHRE, JR., University of Cincinnati, *Vice-President*

11. The Proposed Field Trip of the Kentucky and Ohio Academies of Science, Geologic Sections.—By C. H. BEHRE, JR., University of Cincinnati, Cincinnati, Ohio.

The field trip proposed is to start at Lexington, Ky., and study the Ordovician and higher rocks to the base of the Mississippian in the Eastern and Southern Blue Grass region. Subsequently, according to the original plans, the trip is to continue eastward into Kentucky, crossing the Pennsylvanian section and studying various economic features southwest of Ashland. Later the latter part of the trip was changed so as to carry it to Western Kentucky, where the crypto-volcanic structure at Jeptha Knob will be visited. Details of the trip were briefly discussed.

12. Some Features of the Surface Deposits of Ottawa County, Ohio.—By G. W. CONREY, Ohio Agric. Exp. Sta., Wooster, Ohio.

Ottawa County is entirely within the lake plain of northwestern Ohio. The surface is almost flat, except in the eastern part on the Marblehead Peninsula and the islands. The highest elevation is about 670 feet above sea level, so this area, following the withdrawal of the glacial ice, was entirely submerged during the early glacial lake stages. Beach deposits exist at elevations which correlate with the Wayne (660), Grassmere (640), and Lundy (620), beaches. During the Wayne and Grassmere stages Marblehead Peninsula existed as an island, and a small area on South Bass Island may have been just above water during the latter stage. During the Lundy stage, in addition to the Marblehead Peninsula, small areas were exposed on Catawba Island, South Bass Island, and Johnson Island. Beach deposits were laid down in favorable places. In the western part of the county, the southwestern corner was above water during Lake Lundy stage. The site of the beach is marked by a belt of very fine sand, which spreads out fan shaped on either side of the Portage River near Elmore. Southwest of the Lundy beach glacial drift is exposed at the surface; elsewhere in the flat part of the county the surface materials are slack-water deposits (silt and clay) varying in thickness from 3 to 10 feet or more.

13. Physiography of the Pioche District, Nevada.—By LEWIS G. WESTGATE, Ohio Wesleyan University, Delaware, Ohio.

Pioche lies in eastern Nevada, in the Great Basin region of faulted mountain blocks. The study of the district, just completed for the U. S. Geological Survey, shows no recent faulting but that the ending of diastrophic movements, including block faulting, has taken place early enough for the blocks to be reduced to maturity by Pliocene time.

14. A Type of Landslide Common in Clay Terraces.—By JAMES K. ROGERS, University of Cincinnati, Cincinnati, Ohio.

The premises here set forth are based on field studies of landslides in clays of the Hudson Valley, clay terraces of the upper Tonawanda and Limestone valleys in western and central New York, respectively, and the clay terrace of Licking River near Latonia, Kentucky.

Certain features seem to characterize this type of slide, which is developed typically in terraces of horizontally laminated clays, undercut by the lateral shifting of stream courses. The first manifestation of instability is bowing up at the toe of the slope. From a study of the profiles of the slides, it seems probable that this upward bulging is due to plastic or viscous flow at no great depth, rather than to the rotational movement of the mass which is apparent in the next stage.

The sliding is usually rapid, taking place along a curved surface or zone. There appear to be three main divisions of the landslide mass: (1) at the head, a down-slipped block or series of blocks, with surfaces tilted into the slope; (2) in the central part, a buckled and disrupted area, with wide fissures transverse to the direction of movement; (3) in the lower part of the slide, an anticlinal ridge or series of ridges, the foremost of which may be over-thrust and often occupies a part of the former stream channel.

15. The Evidence in Favor of Climatic Differences During Ordovician and Silurian Times.—By AUG. F. FOERSTE, Dayton, Ohio.

On account of the presence of corals in Arctic faunas it usually is assumed that polar climates were warm during Ordovician and Silurian times. However, we know nothing of the ability of early corals to adapt themselves to polar climatic conditions. They belong to entirely extinct divisions of the coral group, and may have had different life conditions in earlier times. On the other hand, the distribution of Ordovician and Silurian faunas lends itself more readily to explanation on the basis of a distribution in an east and west direction, than in a north and south direction. Thus there is a possibility that this distribution is in part due to climatic conditions, those forms farther north being better adapted to colder areas.

16. Conodonts of the Ordovician.—By W. H. SHIDELER, Miami University, Oxford, Ohio.

Although rarely observed, conodonts were fairly common in the Ordovician and include most of the dominant Devonian and Mississippian genera. Several species are described and figured.

17. *The Influence of the Canadian and Baltic Shields of Pre-Cambrian Rocks on the Distribution of the Ordovician and Silurian Faunas of Northern America and Europe.*—By AUG. F. FOERSTE, Dayton, Ohio.

Both the Canadian and Baltic shields are surrounded by Cambrian, Ozarkian, and Canadian strata, followed at greater distances by the higher Ordovician and Silurian. These shields are of such a large size that faunas passing across the Atlantic north of them become widely separated from those passing south of them. Such faunas as the Racine and various members of the Anticosti series of strata, which lie south of the Canadian shield, have their affinities with strata occurring south of the Baltic shield, but are not known to occur along the northern border of either shield. Migration of Racine faunas from Europe to America across the Arctic is highly improbable.

18. *The Richmond Group in the Nashville Basin.*—By W. H. SHIDELER, Miami University, Oxford, Ohio.

In the Goodlettsville region the basal division of the Richmond, the Arnheim, is followed by a few feet of unfossiliferous strata, and these by heavy limestones carrying a reduced Fernvale fauna, with no higher Richmond beds.

North of Gallatin the section shows the normal succession of the Cincinnati Province—Arnheim, Waynesville and Liberty, with no evidence of Fernvale. The Liberty fauna is that of the Bardstown Kentucky reef, much reduced.

Between Goodlettsville and Gallatin the Waynesville thins westward into the barren strata beneath the Fernvale, while the Fernvale thins eastward above the Waynesville. The position of the Fernvale in the generalized Richmond section is then at least post-Waynesville.

19. *The Correlation of the Silurian Section of Adams and Highland Counties with That of the Springfield Area.*—By AUG. F. FOERSTE, Dayton, Ohio.

In descending order, the Silurian strata of Highland and Adams Counties include the following formations: Peebles dolomite, Lilley formation, Bisher formation, Alger clay, Dayton limestone, Brassfield limestone, and an unnamed argillaceous formation related to the Edgewood formation of Missouri and southern Illinois. The Silurian section of the Springfield area includes: the Cedarville dolomite, Springfield dolomite, Euphemia dolomite, Massie clay, Laurel limestone, Osgood clay or argillaceous rock, Dayton limestone, and Brassfield limestone.

Of the rocks in Highland and Adams Counties the Peebles, Lilley, Bisher, and Alger are not known to occur in the Springfield area. The Peebles is equivalent to the Guelph of Canada, and therefore belongs above the Cedarville of the Springfield area, which is equivalent to the Racine of Wisconsin, the Racine being directly under the Guelph in that state.

The Bisher is equivalent to the upper part of the upper Clinton of New York, while the Euphemia dolomite is approximately equivalent to the Byron of Wisconsin. Between the Euphemia and the Bisher occur in descending order the Louisville limestone, the Waldron shale, and the Laurel limestone of Indiana.

Professor Orton used the name "West Union" for the Bisher in Adams and Highland Counties, and for the Euphemia in the Springfield area and in regions west of Springfield. The name West Union never was properly defined from any exposure near West Union. No fauna of a diagnostic character ever was listed by Orton from the West Union area, nor from Highland County. Orton's section at Hillsboro does not clearly indicate just how far upward his West Union at that locality extends. His use of the name West Union in areas farther north was incorrect, and for the sake of clearness it would be better if the term West Union were dropped entirely.

20. *A Study of Some Devonian Coral Genera.*—By GRACE A. STEWART, Ohio State University, Columbus, Ohio.

A study now in progress on the corals of the middle Devonian rocks of Ohio has revealed the uncertain and inconstant use of generic names as applied to a number of Devonian genera. This paper discusses a few of these genera to illustrate the problems involved, and presents conclusions concerning them.

21. *A New Interpretation Concerning the Hillsboro Sandstone.*—By J. ERNEST CARMAN AND ERNEST O. SCHILLHAHN, Ohio State University, Columbus, Ohio.

A restudy of the Hillsboro sandstone of Highland County has shown that certain exposures, formerly interpreted as sandstone layers interbedded in the Greenfield and the Niagaran dolomites, are really masses of sandstone completely enclosed in the dolomites not more than 30 feet below the Silurian-Devonian disconformity, which here cuts across the Greenfield and Niagaran dolomites. The other exposures are of sandstone resting on either the Greenfield or the Niagaran at the horizon of the disconformity.

The Hillsboro is interpreted as including two types of deposits of the same age: (1) discontinuous sand deposits laid down on the post-Silurian eroson surface; (2) sand that was washed down into existing cavities beneath this eroson surface. The Hillsboro is younger than the erosoin interval which came after the formation of the Greenfield dolomite of late Silurian and older than the Ohio shale of Upper Devonian, which, in Highland County lies next above the Silurian-Devonian disconformity. It is in the same hiatus as the Sylvania sandstone of early Devonian age in northwestern Ohio.

22. *The Faunas of the Cumberland Sandstone.*—By PAUL H. DUNN, Miami University, Oxford, Ohio.

There exists a rather interesting fauna in the Cumberland Sandstone, mostly ostracods, that may point to a possible relationship between that formation and the Saluda phase of the Upper Whitewater.

23. Facies of the Borden Rocks of Southern Indiana.—By PARIS B. STOCKDALE, Ohio State University, Columbus, Ohio.

Completion of three summers' field study of the Borden (Knobstone) group of Mississippian rocks in southern Indiana has revealed a stratigraphic situation with numerous complexities. The writer's work involved a connected study of the rocks from the Ohio River in southern Harrison Conty, northward to the glacial boundary in Morgan County, a distance of about 125 miles.

The Borden rocks, often correlated with the Waverly of Ohio, lie between the Rockford (Kinderhook) limestone and the Harrodsburg (Warsaw) limestone. They represent a sharply delimited stratigraphic unit of predominately clastic material. In the Ohio River localities, the group is about 500 feet thick, and in central Brown County it is 750 feet or more in thickness. Work of previous investigators has been incomplete and disconnected, and attempts to subdivide the group into stratigraphic units have been made only locally. The results are, therefore, not applicable thruout the entire outcrop area. The writer's studies reveal that the Borden group consists of five geological formations, each recognizable thruout the entire area. The formations carry sharply defined members which are locally traceable. In order of superposition the names of the formations, all but the lowest one of which are suggested by the writer, are as follows:

Edwardsville
Floyds Knob
Carwood
St. Joseph
New Providence

The chief source of confusion in the past has been the failure to fully realize that each formation displays numerous facies. There is much lithologic dissimilarity in a given formation between areas not widely separated. Perhaps the outstanding case is that of the Carwood formation which displays seven distinct facies over the 125 mile outcrop strip. In addition to the lithologic facies, faunal facies add difficulty to recognition of the different formations. The various facies have been appropriately named.

24. Primitive Characters of the Fresh Water Bryozoans.—By GEO. B. TWITCHELL, Cincinnati, Ohio.

Most of the recent marine bryozoans are too highly differentiated to be useful in determining the character of the organism that built up the fossilized zooecia of the Paleozoic bryozoans.

The fresh water bryozoans are usually considered as recent accessions to the fresh waters, but their simple, primitive structure suggests an old ancestry. The object of this paper is to present an account of these primitive characters and their relationship to the architecture of Paleozoic bryozoans.

The statoblasts (characteristic of many fresh water bryozoans) are usually considered a late adaptation to fresh water conditions,—i.e., frequent changes of temperature, dessication, and so forth. This

idea is emphasized by the fact that such resting bodies are also found in fresh water sponges and not in marine forms; resting bodies cccur even in fresh water protozoa but not in the marine types.

An adaptation to fresh water conditions may not be the last word in accounting for statoblasts for statoblasts do occur (though rarely found) in marine Ordovician bryozoans.

The habit of growth of the primitive entoproct Urnatella, is very similar to that of the trepostomatous bryozoans of the Paleozoic. This is especially shown in the arrangement and characteristics of the immature and mature regions of a definitely segmented stem. There are no other living bryozoans whose structure approaches that of the Trepostomata so closely.

While these analogies are very suggestive, they cannot as yet be used for drawing more than tentative conclusions. More study is needed.

25. *Outline of the Geology of Bermuda.*—By A. C. SWINNERTON, Antioch College, Yellow Springs, Ohio.

Volcanic activity was the first event in the history of Bermuda. Although no igneous rocks are found at the present surface, the volcanicity is known from the shape of the island mass and from the core of a well drilling. Erosion of the cone was possibly accompanied by slight subsidence. The following episode is represented by foraminiferal and fragmental marine limestones with some aeolian limestones, which together are called the Walsingham formation. Next in sequence occurred at least one period of uplift during which erosion produced a thick soil and initiated the present solution caverns. The Devonshire formation marks a thin marine overlap and is in turn followed by a complex succession of lightly cemented aeolian limestones and soils—the Paget formation of Verrill.

The age relationships are still uncertain, but there is the possibility that the physiographic changes represented by the sediments may be correlated with the Pleistocene glacial and interglacial episodes.

R. W. Sayles's investigations in Bermuda are contributing greatly to the knowledge and interpretation of the aeolianites and interbedded soils. The author's work on the Bermuda caves was an effort to reduce the known facts of change of level to a quantitative basis.

26. *The Origin of the Devonian Cherts of Central Ohio.*—By LEWIS G. WESTGATE, Ohio Wesleyan University, Delaware, Ohio.

Recent publications by Tarr have held that cherts are contemporaneous gel formations on the ocean bottom. The study of the cherts of the Columbus and Delaware limestones indicate that they are replacements of limestones by silica after the deposition of the limestone but before uplift above sea level.

27. *More Exact Geology.*—By GEORGE D. HUBBARD, Oberlin College, Oberlin, Ohio.

The author calls attention to the acoustic method for determining the form of the ocean floor. Each year also brings more accurate determinations of the distribution of salts and temperature in the sea,

which, when taken in connection with the calculations of depth, gives greater accuracy to the work of sonic depth finders.

Studies in sedimentation are very fruitful. Not long ago good geologists laughed at the idea that pebble shapes meant anything more than the kind or structure of the rock from which the pebbles came.

Once a tilted peneplain interpreted the topography of southern New England. Now measurements and carefully drawn profiles are showing that neither a tilted peneplain nor a series of plains of marine denudation fits the topography but several cycles of erosion with measured uplift between them.

Study of thin sections and of polished surfaces of metallic ores reveals so much more than could be seen in hand specimens, that economic geology is revising many of its conclusions. For example, the New Jersey zinc ores have been called igneous injections, bedded sediments remade, contact metamorphic deposits, and magmatic replacements, but the above more accurate methods of getting at the inmost relations of the minerals have shown that the deposits are metasomatic replacements in pre-Cambrian limestone, dehydrated and recrystallized by long continued, regional metamorphism before the arrival of Paleozoic time.

Let us work all areas of the world carefully and introduce thorough comparative studies. Let us measure and weigh, think and interpret again all in the interest of more exact geology.

28. Some Structural Features in Rocks Induced by Glacial Movement.—By WALDO S. GLOCK, Ohio State University, Columbus, Ohio.

In northeast Columbus the upper beds of an exposure of shale were found crumpled against a wall of undisturbed shale in such a fashion as to suggest that the position and deformation resulted from shove by the ice front. An overturned fold and two thrust faults in the squeezed materials indicate a strong eastward component in the ice movement. An illustration of asymmetrical folds in gravels induced primarily by ice drag is given for purposes of comparison.

29. Marl Balls of the Miami Valley.—By JOHN T. ROUSE, University of Cincinnati, Cincinnati, Ohio.

When Huffman Dam, a part of the Miami Conservancy Project for the prevention of floods in the Miami Valley, was constructed on the Mad River 4 miles northeast of Dayton, excavations were made in the valley to obtain gravel for use in building the dam. As a result of these excavations a lake, one-half mile long and one-quarter mile wide, was formed on the west side of the river above the dam.

Along the nearly vertical shore, five feet below the flat valley floor and continuous around the lake, is a layer of gravel incrusted with marl. In extreme cases small pebbles form the centers of large porous marl balls 16 to 18 inches in diameter.

In the discussion a more detailed description of the marl balls and their occurrences is given, several papers dealing with similar studies are reviewed, and an attempt is made to show that these represent deposition, in situ, around pebbles in an extinct lake.

30. *Effects of Compaction in Coal-Bearing Strata.*—By EDMUND M. SPIEKER, Ohio State University, Columbus, Ohio.

Irregularities in coal-bearing strata are commonly due to differential subsidence or uplift or both, with resulting differential deposition, and perhaps also erosion, of both coal and other sediments. Differential compaction may be another important factor, particularly in local irregularities. If the transformation of peat from the time of burial to the stage of bituminous coal involves the amount of compaction commonly agreed upon by students of coal, then the lateral juxtaposition of peat and sand or clay, in situations such as channels, abrupt ends of swamps, and other places where peat growth or accumulation was irregular, ought to result in considerable differential compaction and consequent stratigraphic irregularity. The results of such differential compaction are of importance to the geologist in the study of (1) closely spaced columnar sections of coal-bearing rocks; (2) "wants," "horse-backs," and some of the similar types of cutout in coal beds; (3) splits, particularly those which develop in short horizontal distance; and (4) any abrupt thickening or thinning of a coal bed.

Study of "wants" in coal beds of Utah led the writer to a consideration of differential compaction as a factor in the history of coal measures, and the present paper is essentially a progress report on an investigation which is extended to include observations in other widely spaced coal fields. Examples of "wants," splits, and columnar sections are cited to show what appears to be the effect of differential compaction, and the importance of the phenomenon in some short-range correlation of coal beds is suggested.

31. *Some Methods of Correlation Based on Heavy Mineral Concentrates.*—By WM. A. P. GRAHAM, Ohio State University, Columbus, Ohio.

Correlation of sedimentary rocks on the basis of contained heavy minerals is not always satisfactory. The percentage of the various heavy minerals is usually the only feature used. Four methods of heavy mineral correlation were used and compared in the study of the four Croixian formations of Minnesota. The isotropic and anisotropic minerals, garnet, tourmaline, zircon, apatite, anatase and cyanite were used. The opaque grains, such as pyrite, magnetite, and ilmenite, were not used in correlation, since they are frequently very badly weathered, making positive identification difficult.

The correlative methods tried were (1) the percentage of each mineral in the individual heavy crops, (2) the number, mineral variety and associations of inclusions in the heavy parts of each formation, (3) the shapes of the grains in each crop, and (4) the texture of each heavy mineral species in each formation.

The results show it is not possible to use the first three methods for correlating these formations, but the fourth method is usable if several samples from the same formation are available for study. There is considerable variation in the percentages of the heavy minerals in samples from the same formation making it necessary to study several samples from each formation before attempting correlation.

32. Edge Facies of Mineralization at Leadville, Colorado (Presented by permission of the Director of the U. S. Geological Survey).—By CHAS. H. BEHRE, JR., University of Cincinnati, Cincinnati, Ohio.

The main ore bodies of Leadville, already repeatedly described, are of the "blanket" replacement type. The center from which the ore-bearing solutions radiated was apparently the Gray porphyry stock at Breece Hill, with its associated high temperature minerals; the greater part of the mineralization of the district, however, is mesothermal.

Studies in Iowa Gulch, five miles east of Leadville, show eastward decrease in the amount of Gray porphyry intrusions, with corresponding differences in mineralization. Whereas manganosiderite and chalcopyrite are at least important constituents near Breece Hill, the ores in Iowa Gulch are almost free from both but bear relatively larger quantities of galena, sphalerite, and barite. In form the Iowa Gulch ore bodies are never well-developed blankets, though structural conditions are similar to those at Leadville; they are fissure fillings or replacements immediately against the walls of fissures, the latter type suggesting solutions more dilute than those at Leadville.

The sphalerite of Iowa Gulch is light-colored, in contrast with the uniformly darker zinc blend that occurs nearer Leadville.

This comparison furnishes another instance of ore zoning. It also favors the inference, already tentatively advanced by others, that light-colored sphalerite has travelled farther than the darker varieties. The Iowa Gulch deposits represent a peripheral or edge facies of the more intense and higher temperature mineralization at Leadville.

33. Drainage Modifications Along the Blue Ridge.—By FRANK J. WRIGHT, Denison University, Granville, Ohio.

A study of the headwaters of the Linville, Broad, and Green Rivers in western North Carolina. Although the Blue Ridge is a westward migrating divide, only a few streams have been diverted from westerly to easterly courses. The changes in these streams have been effected since the close of the second (Asheville) cycle. The upper portions of their drainage basins still preserve the Asheville level, which rises at some points to within two hundred feet of the older or Upland level.

D. THE SECTION OF MEDICAL SCIENCES.

DR. ALBERT P. MATHEWS, University of Cincinnati, *Vice-President.*

34. The Effect of Raw and Boiled Yeast on the Motility of Excised Rabbit Intestine.—By F. A. HITCHCOCK, J. B. BROWN AND H. E. HAMLIN, Ohio State University, Columbus, Ohio.

The effects, if any, of yeast on the gastro-intestinal tract have recently been much discussed largely on account of claims made for yeast by commercial yeast companies. We have investigated the

effects of both raw and boiled yeast using the method originally described by R. Magnus (1904). We find that raw yeast when present in concentrations of 0.5 to 2.0 grams per hundred cc. of solution has a marked inhibiting effect causing a cessation of motility as well as a pronounced drop in tonus. This effect is often slightly delayed and may then be preceded by a period of fifteen to thirty seconds during which the tonus is increased. Boiled yeast in similar concentrations has almost exactly the opposite effect. The tonus of the intestinal strip is increased to a marked degree and often the motility is increased. The increase in tonicity is usually preceded by a very temporary decrease in tonus. If the suspension of yeast is perfused through the lumen of the intestine concentrations ten times as great as those noted above produce no effect at all. Many other substances produce similar effects. Aqueous extracts of the gut wall, of baked beans, of clover and asparagus act similarly to boiled yeast, all showing a stimulating effect. We were unable to verify the conclusions of Polansky who reported that it was the vitamin B content of the yeast that produced the action on the intestine.

35. *Correlative Activities of the Digestive Tract in the Domestic Fowl.*—By D. W. ASHCRAFT, Ohio State University, Columbus, Ohio.

Comparing, by various methods, the activity of the crop of the normal bird with that of the decerebrate bird, no appreciable differences were observed. Further study of the decerebrate bird reveals that no material difference in crop movements occur before and after incising the skin and fascia over the crop and esophagus. A fistula through skin and crop with balloons in situ did not alter its activity. Hunger contractions of the crop invariably result in restlessness of the bird. Less frequently thirst and defecation are factors which also cause restlessness. The form of the curve of contraction by the balloon method, show that the type of contraction of the gizzard is variable, depending upon the position of the balloon in the cavity of that organ. In hunger, the proventriculus and gizzard are vigorously and continuously contracting.

36. *Adrenalin and Muscular Fatigue.*—By R. J. SEYMOUR, Ohio State University, Columbus, Ohio.

Experiments were carried out to test the possible effect of adrenalin in relieving and preventing muscular fatigue. Ergographic records taken until complete fatigue occurred, followed by 5 minute rest intervals showed no effect when adrenalin was injected intra-muscularly at the beginning of a rest period. In other experiments adrenalin (½ to 1 cc. of 1 : 1000) injected intra-muscularly had no effect whatsoever upon the fatigue curve. Similar experiments were tried, giving adrenalin (2 cc. of 1:1000) thru the sublingual lymph spaces. These likewise were ineffective in the prevention or relief of fatigue.

37. *The Blood Pressure of the Common Wood-chuck.*—By H. E. HAMLIN, Ohio State University, Columbus, Ohio.

The blood pressure of a male wood-chuck, caught February 3, 1929, was measured by the standard mercurial manometric method. This animal had come out of hibernation, and the measurements were made March 11, 1929. It was kept under ether-urethane anesthesia throughout the experiment. The blood pressure measurements were made from the carotid artery. The normal mean arterial pressure varied from 108 mm. to 126 mm. Hg., which compares favorably with other mammals. The normal pulse rate under these conditions varied from 180 to 204 beats per minute. Faradization of the vagi and crural nerves brought about reactions from the cardio-vascular mechanisms similar to those obtained from other mammals. Likewise adrenalin (1 cc. to ½ cc. of 1:50,000) caused characteristic rises in blood pressure and increases in pulse rate.

38. *The Treatment of Diabetes Mellitus with a Plant Extract Rich in Vitamin "B."*—By CLARENCE A. MILLS, M. D., Department of Internal Medicine, University of Cincinnati, Cincinnati, Ohio.

It was found that an acid-alcoholic extract of plants rich in Vitamin "B" greatly stimulated the appetite and growth of children and warded off upper respiratory infections. Since insulin is used in diabetes to stimulate the burning of glucose and thereby stop infections, it was thought advisable to try the vitamin extract in diabetes. Several cases, studied in Peking, China, showed a prompt disappearance of sugar from the urine, and a stabilization of the blood sugar at levels near normal, when given the extract. These cases were reported last year*. This winter it has been tried on several patients in Cincinnati, with definite results, although not so striking as were obtained in China. It rarely fails, however, to eliminate the infections, which are the bane of diabetics, and to give added strength and vigor.

The study is being carried on to ascertain the full *value of such treatment.*

E. THE SECTION OF PSYCHOLOGY.

DR. SAMUEL RENSHAW, Ohio State University, *Vice-President.*

39. *Why Do Circles Appear Ellipitical When Seen in the Stroboscope?*—By W. K. WILSON, Ohio State University, Columbus, Ohio.

Explaining the horizontal shortening of figures seen in the stroboscope has been an interesting problem in the psychology laboratories for many years, and many theories have been advanced as to the probable cause of this phenomenon. The most prevalent among these has been the theory that the shortening is due entirely to the speed of the drum in which the figures are revolving.

* Amer. Jour. Med. Sci., 1928, 175, pp. 376.

The writer denies the validity of this claim, assigning the cause of the shortening to other factors entirely independent of the speed of the drum. His theory is that "with the size of figure, diameter of drum, and width of slit constant, the amount of shortening varies with the distance of the eye from the edge of the drum." This theory as stated applies to the cylindrical stroboscope, with figures and drum revolving as a unit, and the figures viewed on the side of the drum opposite the slit, so that slit and figures are moving in opposite directions.

The proof of this theory was set forth in the following manner: A circular piece of paper representing the drum was pivoted with a pin on a piece of cardboard, with the figure 'f,' the slit 's,' and the eye E marked in their respective positions. The ends of 'f' were marked 'k' and 'l,' 'k' being the end first appearing through the slit to the eye at E, and 'l' being the last appearing end. 'K' was designated as the initial point and 'l' as the terminal point. The edges of the slit were marked 'm' and 'n,' 'm' being the edge first to arrive at a given point under counter-clockwise rotation.

The drum was rotated to the position where 'k,' 'm' and 'E' formed a straight line. At this position 'k' was just appearing to the eye at E. The location of 'k' was marked as a_1 on the cardboard at the edge of the drum. Then the drum was rotated further to the position where 'l,' 'm' and 'E' formed a straight line. At this position 'l' the terminal point, was just appearing to the eye; the position of 'l' was marked b_1 on the cardboard. The arc a_1b_1 was then demonstrated to the arc be within which the entire figure 'f' could be seen from 'E.' Although the entire figure was seen within the arc a_1b_1, it is only for very small values of 'd' that the whole figure is seen at any one instant. Instead, it is seen in a series of successively appearing parts,—the size of those parts again depending upon the value of 'd.' With the drum rotating at a rate known as the optimum rate these parts are merged by the after-image effect into a unitary figure and the brain receives the impression of a complete figure.

Using small 'e' to designate the arc a_1b_1, 'r' the radius of the drum and 'd' the distance of the eye from the nearest edge of the drum, 'e' may be calculated for varying values of 'd' by the formula:

(1)
$$e = \left[\sin^{-1}\left\{\frac{r}{r+d}\cdot\left(2\sin\frac{f}{4}\cdot\cos\frac{s}{4}\right)\right\}\right] + \frac{f}{2}$$

where 'f' is the horizontal length of the stroboscopic figure (the diameter, in the case of circles), and 's' is the width of the slit. The linear values of these may be used as angular dimensions in the formula and then 'e' may be read directly as a linear dimension although mathematically it is an angular dimension.

Next the drum was set again with 'k' at a_1 then rotated until 'k,' 'n' and 'E' formed a straight line. At this position, marked a_2, 'k' was just passing out of vision, having been constantly in vision throughout the short arc a_1a_2. By similar procedure it was shown that every detail at 'f' is visible IN MOTION under an arc equal to a_1a_2, and it is

this seen motion through a short arc that produces the blurred edges of the stroboscopic figures.

Although for ordinary distances of the eye from the drum ('d' values) all of the figure 'f' is not visible at the same instant, the maximum amount is visible when the slit 's' is directly in front of the eye. The formula for calculating the size of the arc 'v' which is visible with the slit so located was derived as:

(2)
$$v = 4\left[\tan^{-1}\left(\frac{2.91}{d}\right) + 1.25\right]$$

for the apparatus used at Ohio State University, where the drum radius equals 134 millimeters and the slit width equals 5 millimeters.

Curves from formulæ (1) and (2) were plotted on the same axes and were found to intersect at a point close to the y-axis. Between this point and the y-axis lie all values for 'd' for which 'v' (formula 2) is equal to or greater than 'f.'

40. General Adaptive Behavior of Idiots and Pre-School Children.—By CECELIA GORSUCH, Ohio Wesleyan University, Delaware, Ohio.

The work with chimpanzees by Kohler, Yerkes, and others, together with the ever growing interest in the pre-school child suggested the comparison of these two groups with that third type of intelligence, the idiot. A group of ten idiots from the Training School at Vineland, N. J., ranging in mental age from eighteen months to four years, were used in experimental situations as nearly as possible like those Kohler reported on in *The Mentality of Apes*. The study is being carried further by presenting the same situations to ten normal children between three and four years of age.

Kohler found evidences of "insight" in the solutions of problems by chimpanzees. The same type of behavior was noted in the case of idiots and has been observed in the present experiments on normal children. The language of human subjects offers a means of interpreting some of their reactions. This is especially true in the idiot group because of the slight inhibition of language habits. An idiot and sometimes a normal child while looking for a stick will talk about a stick almost constantly.

Many characteristics of primate behavior as reported by Kohler are evidenced in the reactions of normal subjects as well as a few striking differences. These differences may be a matter of physical development, training, potentiality for further growth in the case of normal children, or a fundamental difference in the type of intelligence of the three groups.

These experiments are by no means conclusive owing to the limited number of subjects and the difficulties encountered which called for a constant revision of technique and adaptation to normal subjects. Certain differences and similarities are, however, manifested; the type of which may be observed, but the reasons for which are at present merely speculative.

41. Orientation in the Earthworm.—By ALVAH R. LAUER, Ohio State University, Columbus, Ohio.

Various authors have reported learning in the earthworm with relatively short periods of training. The present study was originally undertaken to determine conditions which might affect the rate of learning. Because of failure to procure the expected results the study raises a number of theoretical questions relative to learning since it has been assumed that the earthworm can be conditioned. While these data will not invalidate the findings of other workers, they suggest that possibly some of the so-called learning of invertebrates is not learning in the strict sense of the term.

Five worms were used at the beginning of the experiment. These worms were isolated and kept in an ice-chest registering around 2° C. Also fifteen control worms were kept in a container in the same place.

A T-maze made of ¾ inch glass tubing was used with electrodes in each turn such that the current could be reversed, or changed from side to side. The lighting conditions were kept as nearly constant as possible but to check the effects of lateral stimulation the control group were put through the maze at each series of trials for the experimental worms. Again, there is reason to believe that a worm will follow its own or another worm's mucous trail. To off-set this factor the experiment was begun by running each experimental worm only three times and following it by another worm which was being conditioned to go in the opposite direction. This was made feasible by the reversible feature of the maze.

However after the usual number of trials in which learning was reported there was no statistical evidence of learning whatsoever and after more than 350 trials (about twice as many as other investigators have secured—nearly perfect conditioning) we have no evidence of learning such a maze.

The worms were run over a period of seven weeks, being kept at a constant temperature, carefully fed, and all precautions taken to guarantee accuracy in results. The data are presented as evidence of the difficulty of conditioning the earthworm in problems requiring orientation to the right or left. Also there is further evidence that the control worms tended to follow the trail of the worm that preceded it altho the total right and left runs showed a chance distribution.

42. The Technical Vocabulary of the Beginning Student in Psychology Together With a Note on the Statistics of Reliability.—By HORACE B. ENGLISH, Antioch College, Yellow Springs, Ohio.

Summary. A vocabulary test devised by C. L. Harlan was given to a group of 37 students at Wesleyan University (Conn.) and of 35 students at Antioch. Results were compared with those published by Harlan.

Antioch was superior to Wesleyan by small but statistically significant amounts, more particularly in the lowest quartile; and both these groups were so strikingly superior to the Idaho groups tested by Harlan that distinct teaching techniques would seem to be called for.

Neither at Wesleyan nor at Antioch was there a significant correlation between grades in psychology and the vocabulary test nor between the test and standard measures of general intelligence. The student comment that standing is determined merely by one's memory of vocabulary is not sustained.

The validity of the Spearman-Brown prophesy formula is submitted to empirical test, using the Vocabulary Test as material. It is shown to lead one to expect, in most cases, a considerably higher consistency between one testing and another than in fact is found.

The concept of reliability is critically examined, and somewhat more exactly formulated as the extent to which a measure is unaffected by chance factors intrinsic to the measuring instrument. Spearman's measure of reliability is rejected as presupposing conditions which can never be known to be fulfilled.

It is proposed to utilize the familiar random-halves correlation as a true measure of reliability as above defined.

The difference between random-halves correlation and the correlation of two "comparable" tests is suggested as a measure of the effect of extrinsic factors upon re-test consistency.

43. *The Prevalence of Certain Misconceptions and Superstitions Among College Students Before and After a Course in Psychology.*—By HARVEY C. LEHMAN, Ohio University, Athens, Ohio.

The writer in collaboration with Dr. Norman Fenton attempted to discover the prevalence of certain misconceptions and superstitious beliefs among two groups of college students; the first group, students entering their first course in psychology, and the second group, students who had successfully completed a course in elementary psychology and also approximately three-fourths of a course in educational psychology. Supertitious belief was found to persist rather generally among the students who had studied psychology. The writers suggest that several class periods in general psychology be devoted specifically to discussion of the more common superstitious beliefs. It is unsafe to depend upon wholesale transfer of training to overcome the student's weakness for phrenology, fortune-telling and various other forms of occultism. A judicious class program in the first course in psychology will involve: (1) Identification of the student's most glaring superstitions by means of the familiar pre-test technique, and (2) direct and specific attack directed toward their elimination.

F. THE SECTION OF PHYSICAL SCIENCES.

DR. E. H. JOHNSON, Kenyon College, *Vice-President*

44. *The Application of X-Rays to the Study of the Structure of Crystals.*—By FREDERICK C. BLAKE, Ohio State University, Columbus, Ohio.

1. After briefly describing how crystals are made up of layers of atoms and illustrating this idea with lantern slides, some of the ways of studying crystal structure were spoken of and illustrated, stress being laid upon the powder method and the rotating crystal method.

2. Various illustrations were given of the powder photographs obtained for pure metals, and for alloys and other crystals, and the question of the actual interpretation of the powder photographs was discussed in a general way with illustrative material.

3. The application of the rotating crystal method to the study of organic compounds and to such crystals as can be obtained in the macro-state was made, with some very interesting illustrative material.

45. *The Importance of Crystal Growth Colloid Chemistry.*—By W. G. FRANCE, Ohio State University, Columbus, Ohio.

Recent investigations employing the "powder" method of X-ray crystal analysis have established the fact that in many colloid systems of the suspensoid type the dispersed phase is made up of ultramicroscopic crystals possessing lattices identical with those of the massive materials. This fact suggests that the crystallographic fields of force effective at the contact of the various crystal faces and the dispersion medium should be a factor in determining the extent of the adsorption process and likewise the degree of stability of the colloid system. One would therefore expect the magnitude of these forces to be dependent upon the crystallographic structure of the various faces, those made up of ions of like charge being greater than those made up of a mixture of like and unlike charges. Several investigators have used this explanation to account for the modification of the crystal habit of sodium chloride when grown in the presence of urea. To further test the validity of this explanation and also to determine the magnitude of the adsorption effects the growth ratios $\frac{[100]}{[111]}$ of the macroscopic crystals of ammonium and potassium alums grown in the presence of various dyes and amino acids were measured by a motion picture method. In all cases in which the foreign material was adsorbed, the adsorption took place preferentially in favor of those faces populated by ions of like charge. The normal growth ratios were therefore reduced. Measurements and calculations of the thickness of the adsorbed layer indicate that in the case of ammonium alum and diamine sky-blue the layer is "less" than monomolecular in thickness. The results of this work indicate that the adsorption is dependent upon (1) residual valencies; (2) polar groups in the adsorbed materials and (3) the inter-ionic distances in the crystal lattice.

46. Formation and Life of the Metastable Mercury Atom.—By M. L. Pool, Ohio State University, Columbus, Ohio.

The formation of large numbers of 2^3P_0 metastable states in mercury vapor at room temperature without at the same time the formation of measurable quantities of other excited states may be effected by using (a) optical excitation to the 2^3P_1 state with 2737 A and (b) collisions of the second kind of this state with nitrogen or water vapor. The amount of absorption of 4047 (2^3P_0 — 2^3S_1) in the excited mercury vapor indicates the concentration of the metastable states. Measurement of the absorption for various time-waits in the neighborhood of 10^{-4} seconds after the interruption of the exciting radiation show that the state decays exponentially with time. The maximum life (or maximum half value time) of 4.2×10^{-4} sec. was observed for 6.8 mm. of admixed nitrogen. Extrapolation to zero nitrogen pressure gives a "natural life" of 7×10^{-4} sec.

47. A Study of Phenol Disinfectants.—By J. R. Harrod, Ohio Northern University, Ada, Ohio.

The purpose of the study is:

1. To investigate the effect of various concentrations of sodium hydroxide in the analysis of phenol disinfectants.
2. To compare the method of analysis developed by W. H. Chapin with the method developed by J. Bennet Hill and to discover, if possible, the reason for discrepancies in the results given by the two methods.

When these disinfectants are treated with sodium hydroxide, sodium phenolate is formed, but equilibrium is established before the reaction is complete if only equivalent quantitives are used. An excess of sodium hydroxide is therefore added to prevent this. A concentration more dilute than 1:6 is unsatisfactory.

The discrepancies in the results of the two methods are due to the fact that the specific gravity of the free phenols and disinfectants are not considered in the final calculations.

48. A New Large C. T. R. Wilson Cloud Expansion Apparatus.—By Gordon L. Locher, Miami University, Oxford, Ohio.

A large C. T. R. Wilson cloud apparatus, which is operated by simply turning a crank, has been built especially to study paths of x-ray photo-electrons in gases. The apparatus is a modification of the Shimizu-Wilson machine and has the advantages of a large cloud chamber combined with the speed and simplicity of operation of the small reciprocating type. The timing of all operations associated with the production of the tracks is automatic.

An investigation of the successive photo-electric action of x-rays, first observed by Auger, is being undertaken. This involves the examination of a great number of stereoscopic photographs of the tracks with a stereo-comparator.

49. Free-Air Pressure Maps as an Aid in Forecasting Winds and Weather Conditions Along Airways.—By LLOYD D. VAUGHAN, Junior Observer, U. S. Weather Bureau, Columbus, Ohio.

In the observations regularly taken at all first order Weather Bureau stations the observed readings of the barometer are first corrected for variations in temperature, local gravity and station elevation, and also for certain errors which are inherent in the instrument itself; so that when the sum of all of these corrections is applied to the observed reading, the result gives the true local or station pressure, i.e., the pressure produced by the weight of the air column situated above that point.

After determining the station pressure it is necessary to reduce this to very nearly the value it would have if the air column should be extended on downward for a length corresponding to the height of the station above mean sea-level. This reduction is carried out by means of a solution of the hypsometric equation, the temperature argument being derived from the mean of the current dry temperature and the dry temperature obtained at the observation taken twelve hours previously.

In actual practice, each station has an appropriate table upon which is given the sea-level values for any station pressure corresponding to each five degrees difference in the mean temperature. The use of this table, of course, makes for much greater convenience and the saving of time in working up the observation.

When these values are collected from all parts of the country and set down upon the sea-level map, the differences thus shown between one place and another then appear as actual differences in atmospheric pressure reduced to one homogeneous horizontal plane, and are not differences due to variations in altitude etc., between the different stations.

It happens, however, that in spite of all of the advantages that it may have, the sea-level map does not often give us a very definite idea as to the actual distribution of pressure and the resultant gradients and wind movements in the atmosphere at a height sufficient to be free of many local surface variations. It is well known that local differences in temperature and the effect of surface friction and turbulence have a very great influence in modifying what might otherwise be a more nearly true representation of conditions aloft.

It has been noted, too, that the location of the center of an area of high or low pressure area is not geographically the same on the sea-level map as it is on a chart showing the pressure distribution at a height of 1 or 2 kilometers and this shift in the location of the center and the consequent trend of the gradients as shown on the upper air map may sometimes provide the only possible indication of what changes may be expected to occur within the next 24 to 36 hours.

So that from the forecaster's standpoint the free-air map may furnish a solution of some of the difficulties involved in correctly interpreting the conditions shown on the sea-level map, besides indicating certain existing conditions which the surface map does not show.

The point which is of particular interest in connection with the airways service, however, is that on the upper air map the *wind direction is along or parallel to the isobars** and the velocity, of course, will be indicated by the steepness of the gradient in that locality; whereas on the surface sea-level map, the friction and turbulence occasioned by the movement over this surface causes the wind to blow *across the isobars at an angle* and local irregularities may also cause the direction of the indicated surface wind to be entirely misleading in indicating what the wind movements are aloft.

A further advantage is that if the free-air maps are found to be entirely dependable in giving accurate information as to the direction and velocity of wind movements occurring in the upper air, it will bring about a considerable saving in the expense which would otherwise be necessary for maintaining a greater number of pilot balloon stations for the purpose of obtaining this same information by direct observation.

This investigation into the methods of charting pressures in the free-air is an attempt to continue some of the work of the late Dr. C. L. Meisinger, who by his wonderful genius and industry had already accomplished so much toward the solution of this extremely difficult problem, when his brilliant career was so untimely terminated by his tragic death in a balloon accident early in 1924.

The reduction of pressures to the 1 and 2 kilometer levels limits these maps to the central and eastern portions of the country only; as the elevation of many of the stations in the western plateau region is much higher than 1 kilometer, and moreover, the barometry of this region presents a very much more complicated and difficult problem than that of the plains and the eastern part of the field; but it is hoped that later, as this work progresses, it will be possible to extend the reductions to higher levels and to draw free-air maps for the entire United States and southern Canada.

The essential basis of the present work is to reduce the pressures from the station values up to the 2 kilometer level, instead of downward to the sea-level plane, and for convenience in this reduction process, use is made of a graphical device which is here called a "Pressure Reduction Nomogram."

A temperature correction is necessary in order to obtain the mean temperature of the air column through which the reduction is made, and the index giving the value of this correction, Meisinger found was directly related to the surface wind direction.

It was not possible to obtain the values for all the station pressures in the construction of the charts which accompany this article, but it was found that an approximation sufficient to illustrate their value and interest in connection with the air-ways weather service could be had by reducing directly from the sea-level pressures to the 1 and 2 kilometer planes, the temperature argument being the current A. M. dry temperature and both the pressure and temperature values being taken from the daily telegraphic signal reports.

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*Assuming a stationary formation and a steady state of adjustment between gradient and wind.

50. *The Return of the Wandering Water Molecule.*—By WILLIAM H. ALEXANDER, Senior Meteorologist, U. S. Weather Bureau, Columbus, Ohio.

The escape, the wanderings and the return of the water molecule constitute one of the longest and one of the most fascinating stories in the vast realm of modern meteorology. These molecules are escaping ceaselessly into the atmosphere in inconceivable numbers and quantity and form one of its most vital elements. It is estimated that, for the world as a whole, sixteen million tons of these molecules enter the air every second. While they escape, in the main, singly, they return in great crowds, or groups, or masses.

It was proposed in the few moments given to this paper to discuss briefly, and, by the use of the lantern slide, indicate some of the interesting and more or less well-known forms in which these molecules return to earth from their wanderings, such as the raindrop, the dewdrop, the snow flake, sleet, hail, rime, glaze, frost, etc. In this way some of the marvelously interesting things revealed by the microscope regarding these visitors from cloudland were pointed out.

51. *Motion of the Ball on a Bowling Alley.*—By L. W. TAYLOR, Oberlin College, Oberlin, Ohio.

This is an experimental study of the motion of the ball on a bowling alley. A recording device registers to hundredths of a second the times of passage of the ball through successive half-meter intervals. The ball is launched by a catapult instead of by hand, in order that the initial velocity may be controlled. The ball passes from an initial sliding motion to final rolling. Systematic deviations from behavior prescribed by the simple theory suggest the way in which the transition occurs from sliding friction to rolling friction.

(This paper is published in full elsewhere in this report.—W. H. A.).

52. *An Adjustable Wall Mounting for Galvanometers and Similar Instruments.*—By B. J. SMYTH, Oberlin College, Oberlin, Ohio.

A simple wall mounting has been devised for supporting instruments which require delicate levelling. The mounting has a slow-motion levelling adjusment about both horizontal axes. The device was on exhibition.

53. *Determination of e/m for the Electron in the Undergraduate Laboratory.*—By FORREST G. TUCKER, Oberlin College, Oberlin, Ohio.

The method is a modification of that suggested by H. Busch, Phys. Zeit., 23; 438; 1922. A low voltage a. c. source is connected to one pair of deflecting plates of a Western Electric Cathode Ray Oscillograph. The straight line trace on the screen is then reduced to a point by means of a uniform longitudinal magnetic field. The equation for e/m is derived by elementary analysis.

54. *Some Applications of Magnetostriction Including a Precise Method of Measuring the Velocity of Sound.*—By MARTIN GRABAU, Wittenberg College, Springfield, Ohio.

This paper comprises a review of the recent researches of Professor G. W. Pierce of Harvard University together with a report upon unpublished and uncompleted work on the application of Magnetostriction to the problem of measuring the velocity of Sound to a greater precision than has hitherto been attained. The minute change in length of a magnetic rod upon being magnetized is utilized to control the frequency of a vacuum-tube oscillator very much after the manner of the Piezo-electric crystal. This phenomenon leads at once to many precise methods for frequency control and measurement. Inasmuch as the length of the magnetostrictive rod varies periodically its face becomes the source of a Sound wave. If this Sound wave is directed against a reflecting surface the returning wave will either aid or oppose the vibration of the rod according to phase difference between the two vibrations. This reaction is observable and yields an accurate measure of the wave-length of the Sound when the reflector is moved along by means of a precision screw. This method is an extension of Professor Pierce's previous experiment involving the reactions on a Piezo-electric crystal source.

THE MOTION OF A BALL ON A BOWLING ALLEY.

DR. L. W. TAYLOR
Professor of Physics, Oberlin College, Oberlin, Ohio

A number of years ago the writer had occasion to work out the theory of the motion of a homogeneous sphere on a plane, with friction. Some of the results invited experimental work. Access to a bowling alley, normally idle during the summer vacation period, recently made this possible.

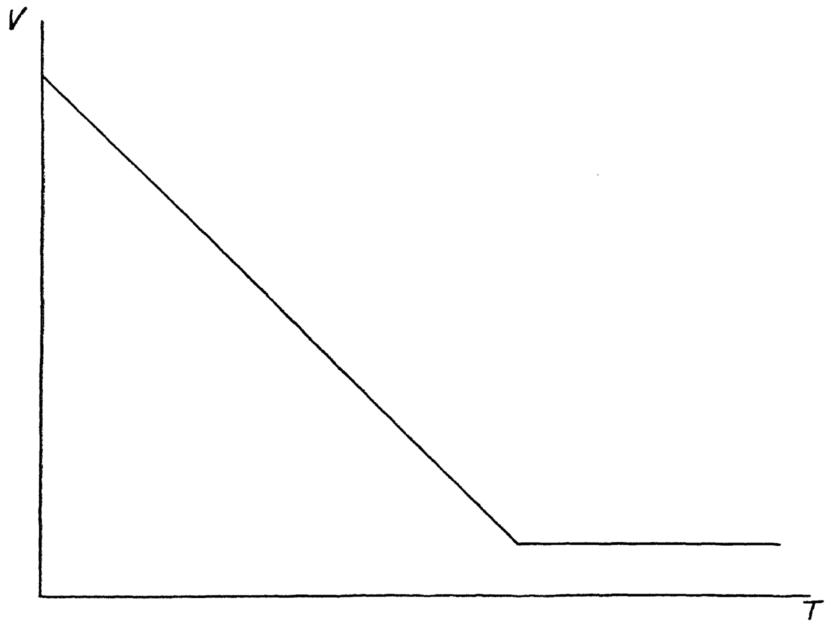

FIG. 1. Theoretical Velocity-Time Relation.

What may be termed the "simple theory" for present purposes, shows that a sphere, projected as described, subject to constant frictional force, ultimately ceases sliding and thereafter executes a motion of pure roll. The transition from sliding to rolling occurs, if the initial projection was without rotation, at the instant that the velocity of the center of the ball becomes five-sevenths of the initial velocity. This is entirely independent of the value of the coefficient of friction.

Furthermore, the time elapsed and the distance travelled when this stage is reached may be expressed by the relations:

$$t = \frac{2v_o}{7a} \quad \text{and} \quad s = \frac{12v_o^2}{49a}$$

respectively, where v_o represents the initial velocity and a the acceleration of the ball.

The velocity—time relation should be straight line up to the point where pure roll sets in. Rolling friction being not measurably different from zero, the velocity is constant from this point on. A discontinuity in the transition from sliding to rolling motion is implied by our assumption of constancy of the coefficient of friction. (See Fig. 1).

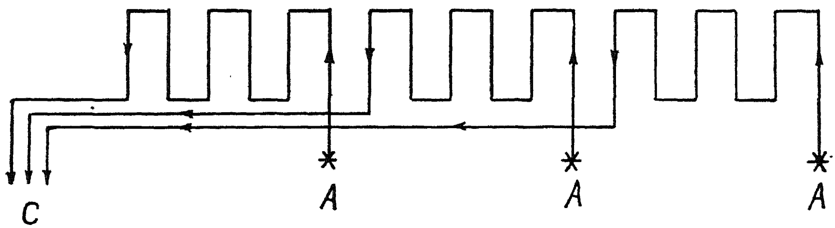

FIG. 2. Arrangement of Arcs (A) and Camera (C) and Course of Light Beams.

These conclusions were subjected to test as follows: A beam of light was reflected back and forth across the alley at a level just below the top of the ball, thence into a camera which carried a moving film, the speed of the film being about ten cms. per second. Every passage of the ball through the beam produced a break in the otherwise continuous line traced by the stationary spot of light on the moving film. More than thirty reflections were involved in the optical system. Since the loss at each reflection was such as to limit us to twelve reflections, the optical system was divided into three parts, with an arc for each part as shown. (See Fig. 2).

The use of sixty-cycle alternating current on these arcs produced one hundred twenty extinctions per second, thus providing a time scale on the film. (See Fig. 3). The section of film shown here illustrates the way the observations were recorded. The interval between successive dots represents one one hundred twentieth of a second, while that between the

successive larger extinctions of the line represents a fifty-centimeter travel of the ball, fifty centimeters being the distance between the mirrors along the alley.

That initial velocities might be reproducible, the ball was launched by a catapult rather than by hand. This consisted of a pendulum swinging on ball bearings, holding the ball in a three-point suspension. (See Figs. 4 and 5). Delivery of the ball was effected by retarding the pendulum with a spring

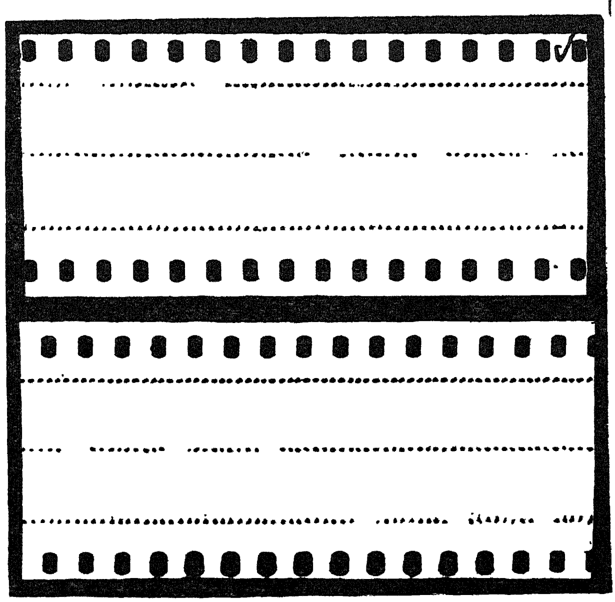

FIG. 3. Sections of Film, bearing typical records.

as it reached its lowest point. A slow-motion adjustment of the length of the pendulum made it possible to deliver the ball tangent to the alley, without audible impact.

Some five hundred records were taken, about equally divided between ten different velocities. The velocity-time relation for seven of these is shown graphically herewith. (See Fig. 6). The two higher velocities placed the transition point beyond the range of our optical system, and hence are not included here, and the lowest velocity is excluded because it reached the transition point before yielding sufficient information concerning the acceleration while sliding.

Qualitatively these curves are not far different from that of the simple theory. Quantitatively there is considerable

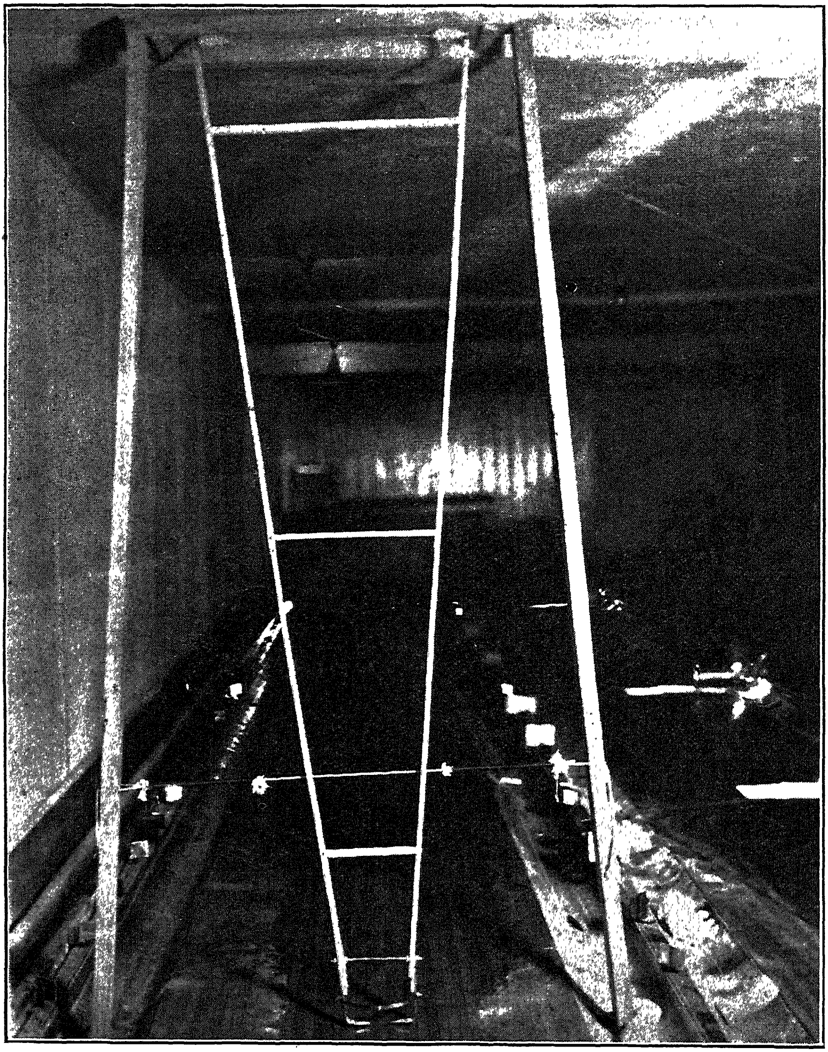

FIG. 4. Catapult. Alley in background; arcs at right.

difference. The passage from sliding to rolling is gradual instead of abrupt, which was really to be expected. This "smoothing out" of the knee of the curve indicates a departure

of the frictional force from constancy. The departure begins to be evident when the relative velocity of the sliding surfaces

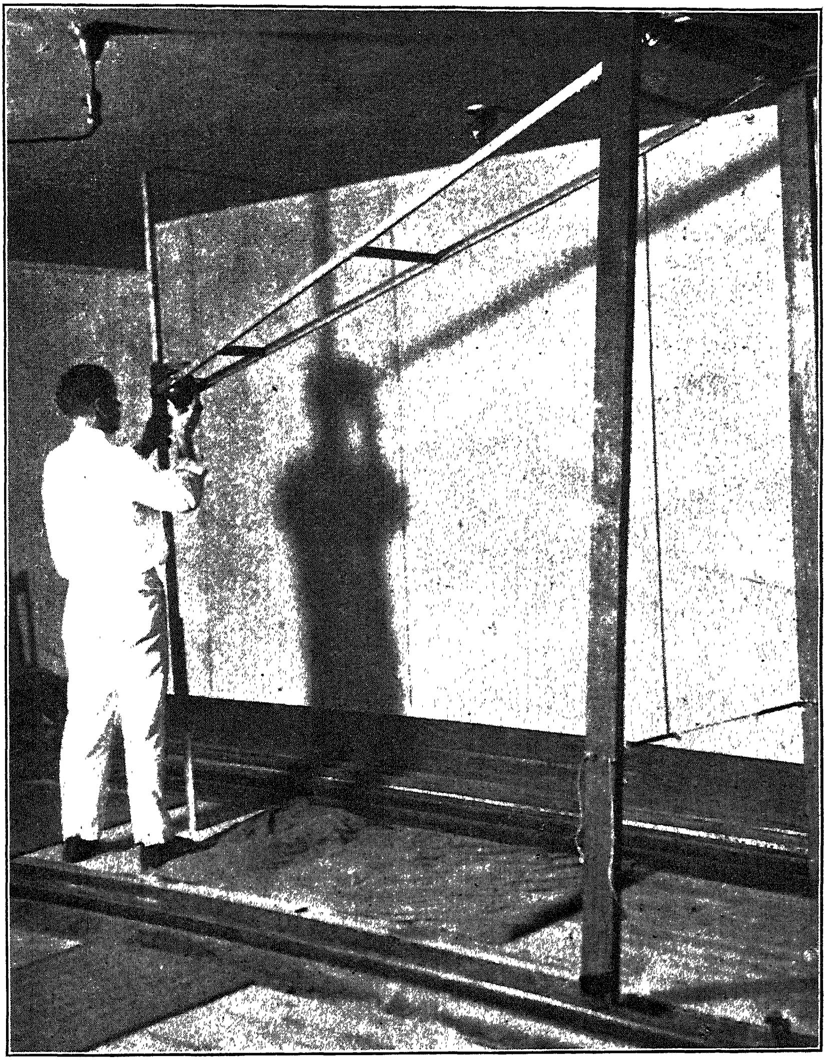

FIG. 5. Method of Launching Ball by Catapult.

becomes less than about sixty cms. per second. But for the law of this departure, we have insufficient information. The establishment of a sufficient number of points on the knee of

the curve would require observations at intervals considerably smaller than the diameter of the ball. This would require an experimental method entirely different from the one used.

The first point of each curve represents the average velocity over the first fifty cms. of travel; therefore, presumably an approximation to the instantaneous velocity twenty-five cms. from the starting point. The actual initial velocity we can only infer by producing the curve back to the velocity axis,

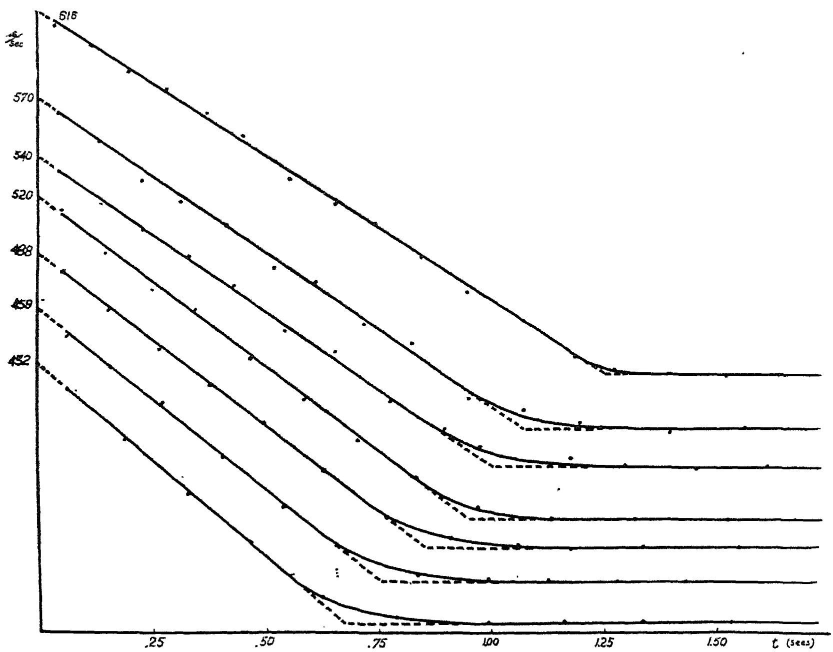

FIG. 6. Velocity-Time Grafs, for different initial velocities.

as shown by the dotted line. This procedure may not be justified. There is some evidence that the friction at the outset is less than that along the larger part of the course. By dusting the alley with lycopodium powder, we found that if the ball was launched by hand, rather than by the catapult, its motion was one of bouncing rather than sliding for nearly if not quite the full length of the alley. The bouncing could not be entirely eliminated by even the most careful adjustment of the catapult, though it could be confined to a region of less than twenty-five cms. at the beginning of the course. That

the average effective friction was the same for the bouncing motion as for the sliding would be a decidedly questionable assumption. There is reason to believe that it is less. In that case the worst possible situation would be zero friction, or the initial velocity approximately equal to the velocity at twenty-five cms. The effect of such an assumption we shall observe in a moment.

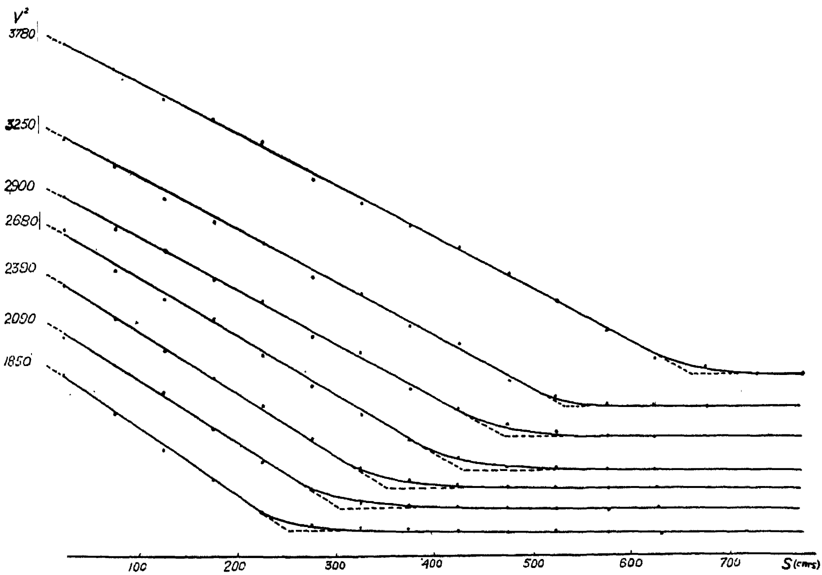

FIG. 7. Velocity-Distance Grafs, for different initial velocities.

The observations give the *final* velocities quite definitely. The simple theory indicates that this final velocity should be five-sevenths of the initial, regardless of the friction. The observations, using the extrapolated value of the initial velocity, place the final velocity consistently three percent lower than the theoretical value. But using the average velocity over the first half-meter as the initial velocity as suggested above, the observed final velocity is higher than the theoretical by two percent. This suggests that the initial velocity is less than the extrapolated value but greater than the average velocity over the first half-meter of travel, a conclusion not at all startling. In other words the final velocity constitutes the most reliable basis for estimating the initial.

The departure from constancy on the part of the coefficient of friction in the region of transition from sliding to rolling renders any test of the other two relations rather inconclusive. Such a test might be made by noting the point of intersection of the dotted extensions of the two straight portions of the curve, a familiar though usually questionable expedient. In this case it yields results which average nearly seven percent higher than the theoretical, basing the calculations on the initial velocity given by extrapolation. Using the smaller initial velocity increases this discrepancy to twelve percent. So a definitely longer time is required to reach the rolling state than the simple theory suggests, even when we attempt to eliminate the effect of decrease of friction in the region of the point of transition.

The final relation, that for the distance travelled when the transition point is reached, may be checked by a velocity-distance graph. (See Fig. 7). Plotting the *square* of the velocity against the distance rectifies the first part of the curve and gives a set which closely resembles the previous one for the velocity-time relation. The slope of these lines represents twice the accelerations. Measurement of these slopes checks within less than one percent the values of the accelerations taken from the previous curves. But the distance travelled by the ball when the transition point is reached fails to check the theoretical value by about the same margin as did the time. The discrepancy is either five or ten percent, depending upon the choice of initial velocities.

We have seen that the value of the coefficient of friction appears to gradually decrease at velocities less than sixty cms. per second. How it decreases we cannot say, except that it appears to vary continuously from that for sliding to that for rolling friction. From sixty up to the maximum of about six hundred cms. per sec., shown in the preceding curve, there is no clear evidence of variation of the coefficient of friction with velocity. The value is not quite the same for different curves, possibly due to the fact that the catapult was moved sideways several times to avoid wearing channels in the alley. In the two high-initial-velocity curves not shown, up to seven hundred cms. per sec., there was unmistakable indication of a larger slope at the beginning than subsequently. The information on the departure from constancy of slope at the beginning

is even more meager than for that at the end. At present all that can be said is that for the velocity range of sixty to six hundred cms. per sec., the coefficient of friction between the composition known as "mineralite" and varnished wood, parallel to the grain is .18, though there is clear evidence that it changes both above and below this range.

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OHIO MOSSES, DICRANALES.*

NELLIE F. HENDERSON.

In the present paper, the writer has treated the Dicranales in the same manner as the Polytrichales and Bryales were treated in previous papers. Some species have been included which have never been reported from Ohio but which, without doubt, are to be found in the state. Probably many others may be found which are not included. The order as presented is comprised of the acrocarpous mosses with a single peristome, the Aplolepideæ. Fissidens has been included in the group although some of the species of that genus are pleuricarpous.

DICRANALES.

Minute to large mosses with usually erect, branched gametophores and the archegonia situated at the tip of the main stalk or of ordinary branches. Peristome single, with the teeth composed of plates made by a deposit on the outer and inner sides of the original cell wall of a single layer of cells; teeth transversely barred, often split; sometimes wanting.

SYNOPSIS OF THE ORDER.

I. Scales three or more ranked.
  A. Calyptra not unusual.
    1. Scales formed of a single layer of cells; plants light to dark green.
      a. Peristome teeth not tortuose.
        1′. Teeth not striate, not regularly cleft, sometimes wanting, GRIMMIACEÆ
        2′. Teeth striate.
          a′. Not cleft to the base, divisions broad. . SELAGERIACEÆ
          b′. Cleft nearly or quite to the base, divisions narrow, DICRANACEÆ
      b. Peristome teeth tortuose. . . . . TORTULACEÆ
    2. Scales formed of three layers of cells; plants pale green or grayish. . . . . LEUCOBRYACEÆ
  B. Calyptra entirely enclosing the sporangium. . . . . ENCALYPTACEÆ
II. Scales two-ranked with edges toward the stalk. . . . . FISSIDENTACEÆ

* Papers from the Department of Botany, The Ohio State University, No. 230.

KEY TO THE FAMILIES OF DICRANALES.

1. Light gray (scarcely green), forming dense tufts in moist shade..LEUCOBRYACEÆ
1. Light green to almost black.. 2
2. Scales in two rows with edges towards the stalk.............FISSIDENTACEÆ
2. Scales in three or more rows, edges not toward the stalk.................. 3
3. Plants black or blackish with colorless scale apices, growing on rocks, GRIMMIACEÆ
3. Plants green to light yellowish-green, or if dark, then on the soil.......... 4
4. Scales papillose, spatulate to ligulate.................................. 5
4. Scales not papillose, or if so, then acuminate.............................. 6
5. Calyptra cucullate; costa often excurrent.....................TORTULACEÆ
5. Calyptra not cucullate; costa not at all or barely excurrent....ENCALYPTACEÆ
6. Very small mosses on rocks; peristome teeth not 2-parted, broad; costa cells homogenous...SELIGERIACEÆ
6. Small to large mosses; teeth 2-parted, narrow; costa cells heterogenous, DICRANACEÆ

GRIMMIACEÆ.

Cespitose mosses; scales blackish, often with colorless apices, lanceolate; seta short, sporangium immersed or emergent, globose to cylindrical, peristome single of 16 papillose teeth, red or yellowish; calyptra small; usually on rocks.

1. Scales crisped, without hyaline point, costa with median guides; sporangium immersed.......................................*Glyptomitrium*
1. Scales not crisped, point usually hyaline, costa with basal guides or homogenous; sporangium immersed or exserted.......................... 2
2. Branches irregular or short; teeth filiform, divided almost to the base, *Rhacomitrium*
2. Branches of almost equal height; teeth undivided or only in the outer half, sometimes none...*Grimmia*

1. GLYPTOMÍTRIUM Brid. (*Ptychomitrium* Fuern.).

Greenish-yellow to blackish, radiculose at the base; scales dense, spreading when moist, costa percurrent or ending below the apex; setae straight, usually clustered; sporangium erect, exserted, peristome inserted below the mouth, teeth usually divided, operculum with a straight point; calyptra campanulate, deeply lobed. Autoicous.

Glyptomitrium incúrvuum (Schwaeg.) Broth. (*Ptychomitrium incurvùum* Sull.). Dark green, densely cespitose, erect, up to ¼ in. tall; scales linear-lanceolate, obtuse, margin plane, costa ending at the apex; lower scales smaller than the upper; sporangium ovoid, operculum almost as long as the urn. Spring. On limestone rocks. There is no specimen in the herbarium but the species is reported as common in southern Ohio by Lesquereux and James.

2. GRÍMMIA Ehrh. Hedw.

Densely cespitose; scales crowded, lanceolate with a hyaline point, squarrose-recurved when moist; lower ones smaller, entire acuminate, concave, plane or revolute; perichaetial scales larger; seta short sporangium rarely exserted, globose, to cylindrical peristome reddish-brown, rarely absent.

1. Hyaline point a long hair; sporangium shorter than the seta....*G. laevigata*
1. Hyaline point short, sometimes not pointed; seta shorter than the sporangium.. 2

2. Scales narrow, obtuse; loosely cespitose; brownish-green........*G. apocarpa*
2. Scales acuminate; densely cespitose; green.............................. 3
3. Sporangium oblong-ovate, smooth.........................*G. pennsylvanica*
3. Sporangium globose-ovate, wrinkled when dry..................*G. conferta*

Grimmia apocárpa (L.) Hedw. ¾–1 in. in height; scales ovate-lanceolate, erect spreading, margin recurved, costa ending at or near the apex, basal cells usually sinuose walled; sporangium immersed, reddish-brown, operculum short-rostrate, peristome reddish-brown, columnella often falling with the operculum. Late spring. On stones. Lake, Clarke, Franklin, Hamilton.

Grimmia confĕrta Funck. Dense cushions of bright green to grey-green mosses; gametophores slender; scales lance-ovate to oblong, denticulate, costa ending at the apex; sporangium wide-mouthed, peristome teeth light red to orange, operculum apiculate. Spring. On exposed rocks. Lake Co.

Grimmia pennsylvánica Schwaeg. (*G. pilifera* Beauv.). Dark green, up to 1 in. or more tall; scales dense, ovate-lanceolate, margins recurved, apex rough, costa ending in the apex, base yellowish; seta about half as long as the sporangium, sporangium immersed, oblong-ovate, smooth; peristome teeth irregularly split. Autumn. Moist shaded rocks. Clarke, Fairfield, Lake.

Grimmia laevigàta Brid. (*G. campestris* Bruch.; *G. leucophaea* Grev.). Loosely cespitose, dark green, hoary because of the hyaline points which are often as long as the rest of the scale; scales dense, larger at the top of the gametophore, ovate-oblong, concave, margins plane, points decurrent along the laminæ; lower scales without the hair point, costa ending in the apex; sporangium elliptical-oblong, smooth, brownish, included; calyptra mitrate, lobed. Spring. Non-calcareous rocks. Reported from Ohio by Lesquereux.

3. RACOMĬTRIUM Brid.

Robust, loosely cespitose mosses, radiculose at the base, procumbent to erect, uniformly foliate, often with short lateral branches; scales hyaline-pointed, squarrose to recurved; seta long; calyptra mitrate.

Racomitrium aciculàre (L.) Brid. (*Dicranum aciculare* Hedw.). Dull green or blackish, 2–3 in. tall, stout; scales erect-spreading, entire or distantly denticulate, costa ending below the apex; sporangium smooth, erect, mouth narrow, oblong-elliptic, brown; peristome teeth cleft to below the middle, short; calyptra smooth at the apex. Rarely found in fruit. Spring. Wet, shaded, noncalcareous rocks. Not reported from Ohio but is in Pennsylvania near our boundary.

SELAGERIACEÆ.

Small mosses growing on rocks; usually unbranched; scales 3–5-ranked, tufted above, the lower ones smaller, lance-subulate, costa cells homogenous; peristome teeth 16; calyptra cucullate; operculum rostrate.

1. Minute, gregareous; alar cells not enlarged.......................*Selageria*
1. Larger, cespitose; alar cells enlarged...............................*Blinda*

1. SELAGÈRIA Br. & Sch.

Stalks rarely branched, 3-angled; scales clasping, basal cells sometimes colored; seta erect, short, sporangium with distinct, stomata hypophysis; peristome teeth simple.

1. Scales entire.. 2
1. Scales denticulate or serrate.. 4
2. On sandstone; seta recurved when moist; sporangium narrow-mouthed, *S. recurvata*
2. On limestone; seta erect, or slightly curved when moist, sporangium wide-mouthed.. 3
3. Scales 3-ranked; plants .1–.3 in. tall, branched.................... *S. trifara*
3. Scales not 3-ranked; plants less than .1 in. tall, simple............ *S. calcarea*
4. Awn long, tapering; seta erect when moist............................ 5
4. Awn short, papillose; seta recurved when moist................ *S. campylopoda*
5. Yellowish-green; peristome wanting............................... *S. doniana*
5. Dark green; peristome present.................................... *S. pusilla*

Selageria doniàna (Sm.) C. Muell. (*Gymnostomum donianum* Smith; *Anodus donianus* Br. & Sch.) Simple; scales dense, erect, straight, channelled; costa filling the awn, perichaetial scales not subulate, sheathing, antheridia in basal buds; seta straight, sporangium ovoid, hemispherical when empty, hypophysis short, peristome wanting, operculum oblique. Summer. Mrs. Britton reports this species for Ohio.

Selageria pusílla (Ehrh.) Br. & Sch. (*Swartzia pusilla* Ehrh.; *Weisia pusilla* Hedw.). Gregarious, bright dark green mosses; scaleless at the base; scales with an ovate-lanceolate base, costa nearly filling the awn, margins recurved; antheridia in lateral buds; seta erect, sporangium oval-pyriform, mouth wide; operculum oblique-rostrate; peristome red or brown, teeth reflexed when dry. Summer. Erie, Logan.

Selageria calcàrea (Dicks.) Br. & Sch. (*Bryum calcareum* Dicks.; *Weisia calcarea* Hedw.). Dark green simple mosses; scaleless below, crowded above, scales erect at the apex, ovate, abruptly subulate, clasping, toothed below, subula entire; costa filling the awn; antheridia in basal buds; seta erect, thick, sporangium erect, pyriform-ovoid, turbinate when dry, brownish, operculum conic-rostrate. Spring. Mrs. Britton reports it from Columbus, Ohio.

Selageria trifària (Brid.) Lindb. (*Weisia trifaria* Brid.; *S. tristichia* Br. & Sch.). Cespitose, gametophores erect up to ⅓ in. tall, with numerous sub-apical branches; scales 3-ranked, erect-appressed, base narrow, entire, costa broad, excurrent, awn slender and rough; seta erect, pale yellow; sporangium ovoid-pyriform, broadly turbinate when empty, hypophysis long, stomatose, peristome red; antheridia in lateral buds. Summer. Reported from central Ohio in Lesquereux and James Manual.

Selageria recurvàta (Hedw.) Br. & Sch. (*S. setacea* (Wulf.) Lindb.). Gregarious, dark green; scales erect-spreading, caniculate, entire; perichaetial scales tubulose; seta yellowish, arcuate, more erect when old; sporangium ovoid to globose, hypophysis short; peristome orange-pellucid. On rocks in shade. Not reported.

Selageria campylopoda Lindb. (*S. recurvata* var. *arcuata* Lesq. & Jas.).. Gregareous, simple; scales crowded, costa ending below the apex, basal cells oblong, marginal ones linear, clear; seta recurved when moist, lid beaked, peristome red or brown. Early fall. Mrs. Britton includes Ohio in the distribution of this species but no definite reports have been made.

2. BLINDA Br. & Sch.

Densely cespitose, branching by apical innovations; scales crowded scarcely secund, lance-subulate, caniculate, cells enlarged and orange colored at the base; sporangium sub-globose, calyptra covering the upper half of the sporangium.

Blinda acùta (Huds.) Br. & Sch. (*Weisia acuta* Hedw.; *Grimmia acuta* Sm.; *Bryum acutum* Huds.). Yellowish-green to brown or black, ⅓-2 in. tall, almost naked below; scales almost entire; seta long; peristome bright red. On rocks. Summer. No report.

DICRANACEÆ.

Gametophores in dense tufts, erect, branched; scales dense, usually falcate-secund, apex usually acuminate; seta usually long: sporangium zygomorphic, cernuous, sulcate when dry; peristome of 16 teeth, usually divided, minutely striate or papillose, sometimes wanting.

1. At least the upper cells of the scales papillose.............................. 2
1. None of the cells of the scales papillose.................................. 5
2. Small mosses, less than ⅓ in. tall............................*Rhabdoweisia*
2. Larger, ⅓ in. or more tall.. 3
3. Alar cells distinctly inflated, often red..............................*Dicranum*
3. Alar cells larger than the others, but not inflated........................ 4
4. Scales sheathing, acuminate or subulate, not crisped............*Oncophorus*
4. Scales not sheathing, not subulate or acuminate, crisped..........*Ceratodon*
5. Alar cells inflated, often colored.. 6
5. Alar cells not inflated.. 8
6. Costa narrow; seta erect; sporangium stomate...................*Dicranum*
6. Costa broad; seta curved; sporangium without stomata.................. 7
7. Calyptra entire; teeth cleft ¾ to the base..................*Dicranodontium*
7. Calyptra fringed at the base; teeth cleft to about the middle, confluent at the base..*Brothera*
8. Sporangium rupturing irregularly.. 9
8. Sporangium opening by a distinct lid.....................................10
9. Sporangium pear-shaped; calyptra mitrate..........................*Bruchia*
9. Sporangium ovoid-globose; calyptra cucullate...................*Pleuridium*
10. Hypophysis inflated, as long as the sporangium..................*Trematodon*
10. Hypophysis short or sporangium without a distinct neck.................11
11. Sporangium nearly actinomorphic and erect; teeth cleft to the base.*Ditrichum*
11. Sporangium mostly zygomorphic, not erect; teeth cleft about half way to the base, confluent at the base.............................*Dicranella*

1. BRŬCHIA Schwaeg.

Green protonema sparingly persistent, gametophores simple; scales crowded at the apex, smaller below, subulate in our species, costa broad; seta short, sporangium immersed or slightly exserted, pear-shaped, calyptra mitrate, neck distinct, stomate.

1. Awn smooth; plants up to ⅓ in. tall; sporangium ovoid-pyriform..*B. flexuosa*
1. Awn rough, plants minute; sporangium ovoid-oblong...........*B. sullivantii*

Bruchia flexuòsa (Schw.) C. Muell. (*Phascum flexuosum* Schw.; *B. brevicollis* Lesq. & Jas.). Small gregareous mosses, about ⅛ in. tall; scales erect-spreading from a convex base, sub-papillose, alar cells not differentiated, antheridia in the axils of the comal scales or in separate buds; seta usually shorter than the cleistocarpous sporangium. On clay soil in bare fields. May and June. Fairfield Co. This species is probably more common than the records would indicate.

Bruchia sullivántii Aust. (*B. flexuosa* Sull.). Small, gregareous, almost stemless mosses; scales broadly ovate at the base, abruptly subulate; seta and sporangium yellow, neck longer than in the preceding species; abundantly fruiting. Wet clay soil. June and July. Reported from Ohio by Jennings.

2. TREMÁTODON Rich.

Low, simple, cespitose mosses with yellowish-green, lancesubulate, clasping scales; costa board, alar cells not inflated; seta yellow, usually erect; neck inflated, stomatose; peristome persistent; calyptra cucullate.

1. Neck as long as the sporangium; scales not crisped when dry, costa filling the awn. . . . . *T. ambiguus*
1. Neck almost twice as long as the sporangium; scales crisped when dry, costa not filling the awn. . . . . *T. longicollis*

Trematodon ambíguus (Hedw.) Hornsch. (*Dicranum ambiguum* Hedw.). Sparingly branched, ⅓–1 in. tall; scales abruptly contracted into a long subulate point, awn serrulate, perichaetial scales longer; seta erect, ½–1½ in. long; sporangium orange, cernuous, neck somewhat strumose, urn oblong, horizontal, operculum long-beaked. Late summer. Old fields among the grass. Not reported.

Trematodon longicóllis Michx. Smaller than the preceding, about ¼ in. tall; sporangium uniformly cylindrical-oblong. Clay soil or sand in old fields. Reported from "northern Ohio" by Lesquereux.

3. PLEURÍDIUM Brid.

Gregareous or cespitose, low, green and glossy mosses, with simple or branched gametophores; scales small, erect-spreading, distant, not crisped, upper ones crowded, long-subulate; sporangium cleistocarpous, immersed, erect, ovoid, without a neck; calyptra cucullate.

1. Perichaetial scales abruptly subulate; antheridia gemmiform in the axils of the upper scales. . . . . *P. alternifolium*
1. Perichaetial scales gradually subulate; antheridia in the axils of the perichaetial scales. . . . . *P. subulatum*

Pleuridium alternifòlium (Dick.; Kaulf.) Raben. (*Phascum alternifolium* Kaulf.). Densely cespitose, less than ½ in. tall, simple or branching by slender innovations; scale base oval, costa excurrent, filling the serrulate awn; sporangium yellowish to brown, operculum apiculate, with a blunt beak. Old clay fields. Not reported.

Pleuridium subulatum (Huds.) Raben. (*Phascum subulatum* Kaulf.). Densely cespitose, less than ¼ in. tall; scales ovate-lanceolate, lower

ones more nearly ovate, minutely denticulate, costa ill-defined, filling the apex; seta shorter than the erect sporangium, yellowish. April-June. Old fields among the grass. Cuyahoga.

4. DÍTRICHUM (Timm.) Hampe.

Small cespitose mosses with simple or sparingly branched gametophores; scales dense, not sheathing, without alar cells, costa broad, perichaetial scales longer; seta erect, lustrous, slender, flexuous; sporangium erect or nearly so, oval to cylindrical; peristome of 16 teeth, split nearly to the base, somewhat twisted, joined by a basal membrane; operculum obliquely conic; calyptra cucullate.

1. Bright green; scales erect-spreading, costa long-excurrent; seta light yellow; paroicous .... *D. pallidum*
1. Yellowish-green; scales erect-appressed, costa short-excurrent or percurrent; seta red or rufous; unisexual 2
2. Scales subulate; lustrous, denticulate and slightly grooved toward the apex .... *D. tortile*
2. Scales lanceolate; rather dull, usually entire, deeply caniculate toward the apex .... *D. vaginans*

Ditrichum tôrtile (Schrad.) Brock. *D. pusillum* (Hedw.) Timm.; *Trichostomum tortile* Schrad.). Usually simple and erect, radiculase below, stalks reddish; scales erect-spreading, somewhat twisted, margins revolute, apex denticulate; seta twisted; sporangium smooth, oblong to oblong-cylindric; peristome reddish. Late autumn. Clay soil in fields or on roadsides. Belmont, Lake, Franklin.

Ditrichum vôginans (Sull.) Hampe. (*Trichostomum vaginans* Sull.; *D. lineare* (Sw.) Lindb.; *D. tortile* var. *vaginans* Grout). Gametophores erect, usually simple, about ½ in. tall; base of scales ovate, concave, margins narrowly recurved; sterile gametophores terete with closely appressed scales; perichaetial scales sheathing; seta ½–1½ in. long; sporangium smooth, brownish, somewhat zygomorphic, erect or inclined; basal membrane short. Late fall and winter. On sandy soil. Fairfield Co.

Ditrichum pállidum (Schreb.) Hampe. (*Trichostomum pallidum* Hedw.). Erect and simple or with erect branches from a creeping base; scales erect-spreading, twisted when dry, lance-subulate, costa long-excurrent; antheridia in buds below the perichaetium; seta yellow, twisted; sporangium reddish-yellow, irregularly sulcate when dry, ovoid-cylindric; peristome reddish. Early summer or spring. On soil in fields and woods. Clarke, Franklin, Greene, Hocking, Lake, Lawrence.

5. CERÁTODON Brid.

Light yellowish-green, radiculose below, branching by slender innovations; sporangium sulcate when old, lid conic; peristome single with a short basal membrane, teeth split nearly to the base.

Ceratodon purpùrascens (Hedw.) Jenn. (*C. purpureus* Brid.; *Mnium purpureum* L.; *Dicranum purpurascens* Hedw.). Densely cespitose, green above and brown below, ½ in. or more tall; scales linear, costa strong, percurrent or excurrent, margins revolute; seta ¾–1½ in. long,

reddish-purple, twisted; sporangium erect, becoming horizontal when old, curved, strumose; calyptra cucullate; antheridial gametophores more slender. May and June. Common on dry soil.

6. DICRANÉLLA Schimp.

Densely cespitose or gregareous, mostly small, sparingly radiculose; scales slender, giving the moss a silky appearance, crowded above more distant below, costa percurrent or excurrent, apical portion usually grooved; seta erect, usually twisted; peristome teeth two or three-cleft; our species unisexual.

1. Costa wide, not well-defined at the base; seta yellowish.................. 2
1. Costa narrow, sharply defined; seta red.................................. 4
2. Costa broad to the shoulder of the scale, then tapering to the apex; sporangium strumose.......................................*D. cerviculata*
2. Costa tapering gradually from the base; sporangium not strumose.......... 3
3. Sporangium erect and actinomorphic.........................*D. fitzgeraldi*
3. Sporangium somewhat cernuous.............................*D. heteromalla*
4. Scales entire; sporangium cernuous, twisted to the right.............*D. varia*
4. Scales serrulate or denticulate; sporangium erect or inclined to the left, *D. rufescens*

Dicranella heteromálla (Dill.) Schimp. (*Bryum heter omallum* Dill.; *Dicranum heteromallum* Hedw.). Cespitose, simple or forking, ¼–1½ in. tall; scales secund, lance-subulate, grooved, faintly denticulate toward the apex, costa to ⅓ the width of the scale at the base; seta ½–1 in. long, flexuous, twisted to the left; sporangium oblong-ovoid, slightly curved, dark brown, when dry bent to one side just below the mouth, increasingly furrowed with age; peristome red, teeth bifid; beak inclined. Autumn. Common in hilly regions. Fairfield, Franklin, Lake, Lawrence, Logan, Summit.

Dicranella heteromalla var *stricta* Br. & Sch. Scales spreading at less than a 45 degree angle; seta longer and more flexuous than in the preceding species. Lake Co.

Dicranella heteromalla var. *orthocárpa* Hedw. Sporangium erect and actinomorphic, becoming furrowed and curved with age. Lake Co.

Dicranella fitzgeráldi Ren. & Card. (*D. heteromalla* var. *fitzgaraldi* Grout). Yellowish-green mosses with usually simple gametophores; scales crowded, erect-spreading, somewhat secund, lance-ovate at the base, subulate, grooved, denticulate near the apex; seta yellowish-red, dark brown when old; sporangium erect, actinomorphic, oblong, almost smooth when dry, not constricted below the mouth. On soil Not yet reported from Ohio but is found in western Pennsylvainia near our border.

Dicranella cerviculàta Schimp. (*Dicranum cerviculata* Hedw.; *Dicranella pusilla* (Hedw.) E. G. Britt.). Yellowish-green mosses with simple gametophores, not more than ½ in. tall; scales erect-spreading, sometimes secund, base ovate, half-clasping, only slightly denticulate, costa excurrent; seta yellowish, flexuous, to ½ in. long; sporangium short-oval, light brown, curved, strumose, irregularly ribbed when dry; lid long rostrate-subulate. Lesquereux reports this species as "very rare" upon the sides of ditches in the cranberry marshes of northern Ohio.

Dicranella vària (Hedw.) Schimp. (*D. rubra* (Huds.) Lindb.; *Dicranum varium* Hedw.; *Anisothecium rubrum* Lindb.). Densely gregareous to cespitose, bright green to yellowish-green, gametophores branching, erect or ascending, usually not more than ½ in. tall; scales erect-spreading, usually somewhat secund, lanceolate, gradually subulate, grooved, margins recurved, only slightly denticulate, costa percurrent; seta reddish, glistening, ascending or erect, twisted to the right, to ½ in. long; sporangium reddish-brown, oblong-ovate, slightly curved, smooth, constricted below the mouth; peristome teeth purplish, cleft to the middle; lid long-rostrate. Autumn or winter. Wet clay soil. This is a widely distributed species, but is not yet reported from Ohio.

Dicranella rufescens (Dick.) Schimp. (*Anisothecium rufescens* Lindb.) Cespitose, reddish to yellowish-green, redder when dry, less than ⅓ in. tall, usually simple; scales pellucid, few, plane, linear-lanceolate, gradually narrowed, slightly denticulate toward the apex, costa percurrent; seta red, twisted toward the left, about ¼ in. long; sporangium dark red, ovoid-globose, erect, actinomorphic, mouth wide; operculum large, conic-rostrate, apex oblique; calyptra cucullate. Summer or fall. Bare moist soil. Not yet reported from Ohio.

7. RHABDOWEÌSIA Br. & Sch.

Small, densely cespitose mosses with 5-angled, branched stalks, radiculose below; scales dense, decurrent, crisped when dry, plane, costa ending below the apex; seta light yellow, erect; sporangium erect, 8-striate, actinomorphic, annulus none; operculum long-oblique rostrate; calyptra cucullate.

Rhabdoweisia fúgax (Hedw.) Br. & Sch. (*Weisia fugax* Hedw.). Usually dark green, ½–½ in. tall; scales linear-lanceolate, acute to acuminate, somewhat concave, crisped when dry, faintly denticulate near the apex; seta ⅛ in. or less in length; sporangium oval, wide-mouthed, brownish, peristome teeth abruptly subulate, papillose. Usually in crevices in sandstone. Spring. Lake, Lawrence.

8. ONCÓPHORUS Brid. (*Cynodontium* Br. & Sch.).

Scales sheathing, ascending to squarrose, long-acuminate to subulate, margins recurved, crispate, never falcate-secund, costa distinct; seta erect; sporangium zygomorphic in our species, strumose, almost smooth when dry, annulus indistinct; peristome of 16 teeth, united at the base, divided to the middle; operculum obliquely rostrate; calyptra cucullate.

1. Scales gradually lanceolate from an ovate base......................*O. virens*
1. Scales abruptly subulate from an obovate base................*O. wahlenbergii*

Oncophorus vírens (Ws.) Brid. (*Dicranum virens* Hedw.; *Bryum virens* Sw.). Robust, cespitose, branching, 2–3 in. tall, bright green above, brown tomentose below; scales smooth, entire or slightly serrate, somewhat crispate, costa excurrent; antheridia sessile below the perichaetium; seta yellow, about 1 in. long; sporangium dark reddish-brown, arcuate. Wet rocks and stony ground. Late summer and autumn. Lake Co.

Oncophorus wahlênbergii Brid. (*Cynodontium virens* var. *wahlenbergii* Sahimp.). Cespitose, branching, 1–1½ in. tall, tomentose below; scales strongly crispate, point flexuose, costa excurrent; seta yellow or reddish, ½ in. long; sporangium short, ovoid, often horizontal, curved; peristome teeth divided below the middle. Not reported.

9. DICRÂNUM Hedw.

Large mosses, thickly tomentose below; scales unusually falcate-secund, lanceolate to lance-subulate, margins plane in the upper half, not thickened, ours with a narrow semiterete costa; sporangium often strumose, annulus present; teeth red, cleft to the middle; calyptra cucullate; our species unisexual.

1. Scales transversely undulate 2
1. Scales not transversely undulate 5
2. Upper cells of the scales longer than broad, porous 3
2. Upper cells of the scales shorter or irregular, not porous 4
3. Scales recurved with spinulose teeth at the margins and back of the costa; setæ clustered .... *D. polysetum*
3. Scales with saw-like teeth, almost smooth at the back of the costa; seta solitary .... *D. bonjeanii*
4. Scales lanceolate, tapering, not papillose .... *D. bergeri*
4. Scales ovate, broadest at ⅓ the distance from the base, suddenly subulate, papillose above .... *D. spurium*
5. Upper cells longer than broad, porous .... *D. scoparium*
5. Upper cells not porous 6
6. Scales distinctly serrulate above, papillose at the back 7
6. Scales entire or serrulate near the apex only, smooth or nearly so 8
7. Small; scales spreading, costa ending in the apex .... *D. montanum*
7. Larger; scales falcate secund, costa often excurrent .... *D. fuscescens*
8. Scales fragile, usually broken at the apex, entire .... *D. viride*
8. Scales not fragile, toothed at least at the apex 9
9. Costa not excurrent, scales strongly crisped when dry, distinctly toothed near the apex .... *D. flagellare*
9. Costa excurrent, scales slightly or not at all crisped, finely serrate .. *D. fulvum*

Dicranum polysètum Swartz, Schw. (*D. undulatum* Ehrh.; *D. rugosum* Brid.). Loosely cespitose, branched, up to 5 in. tall, glossy; scales long-acuminate, wide at the base, sharply serrate in the outer half, inner half recurved, strongly secund; a gray tomentum over the stalks; setæ copper-colored; sporangium cernous, arcuate, lid with a long subulate rostrum. On soil. Fall. No reports.

Dicranum bonjeànii DeNot. (*D. palustre* LaPyl.). Loosely cespitose, branched, 2–3 in. tall, glossy; scales dense, only slightly secund, long-tapering, lanceolate, finely serrate, slightly undulate, costa narrow; sporangium slightly cernuous, arcuate, slightly striate, yellow; lid long-subulate. Late summer. On wet soil. Ashtabula, Fairfield, Lake.

Dicranum bêrgeri Bland. (*D. schraderi* Web. & Mohr.). Densely cespitose, yellowish-green; scales appressed, sub-secund, lanceolate, obtuse at the apex, undulate, sharply dentate on the outer half and back, costa not reaching the apex; sporangium obscurely striate; seta pale. In bogs. There is no specimen in the herbarium although it is listed as common in Beardsley's catalog.

Dicranum spùrium Hedw. Densely cespitose, branched, 1–1½ in. tall, scales dense, distinctly undulate, slightly secund, serrate at the edge and on the back, lanceolate, broad-ovate at the base, costa subpercurrent, perichaetial scales tubulose; seta solitary, 1 in. long, slender, yellowish-red; sporangium arcuate, cernuous, strumose, striate when dry, red at the mouth. Spring. On rocks and sand. No definite reports.

Dicranum scopàrium (L.) Hedw. (*Bryum scoparium* L.). Loosely cespitose, ½–2½ in. tall, yellowish to dark green; scales dense, long and slender, acuminate, concave, not undulate, serrate in the upper one-fourth, strongly secund, with 4 lamellæ on the back; seta single, reddish, glistening; sprangium reddish-brown, arcuate; operculum with a long curved point. On soil, logs and stones in the woods. Late summer and fall. Champaign, Clarke, Fairfield, Hamilton, Holmes, Hocking, Knox, Lake, Lawrence, Licking, Logan, Ross.

Dicranum flagellàre Hedw. Densely cespitose, erect, 1–1½ in. tall, deep green, radiculose below; scales somewhat falcate-secund, gradually lanceolate, involute to near the apex, serrate at the apex, costa percurrent, the upper scales often with slender flagellate branches in their axils; sporangium erect, cylindrical, actinomorphic, striate, slightly curved when dry; tips of the teeth hyaline; lid long-rostrate. Summer. Decaying wood and bases of trees. Champaign, Clarke, Fairfield, Franklin, Lake, Licking, Montgomery.

Dicranum montànum Hedw. Densely cespitose, light green, erect, ¼–½ in tall; scales secund or spreading, much crisped when dry, linear-lanceolate, concave, serrate near the apex, papillose on the back, basal cells brownish; seta single, erect, about ½ in. long; sporangium yellowish, plicate, oblong-cylindrical; teeth cleft nearly to the base; lid long-rostrate. Early fall. Rotten wood and tree trunks. Champaign, Lake.

Dicranum fuscêscens Turn. Cespitose, yellowish-green, 1½–2 in. tall, tomentose; scales dense, narrowly lanceolate, concave, entire or slightly dentate, costa percurrent or excurrent, to ½ the width of the scale at the base, variable in margins and surface; seta single ½–¾ in. long, light yellowish-brown, sporangium erect, oblong-oval, striate when dry, hypophysis short and tapering, lid with a point as long as the sporangium. Autumn. On rocks, wood, or base of tree. Lake, Logan.

Dicranum vìride (Sull.) Lindb. Densely cespitose, light to dark green, ¼–¾ in. tall; scales dense, spreading, narrowly lanceolate, concave, entire, minutely serrate at the tip, costa percurrent, crisped when dry; sporangium oblong, erect or slightly curved when dry. Summer. On wood. Champaign, Clarke.

Dicranum fùlvum Hook. (*D. interruptum* Br. & Sch.). Silky, light green cespitose mosses, about ½ in. tall, brown radiculose below; scales dense, linear-lanceolate, not crisped when dry, finely serrate in the outer portion, secund, costa distinct, slightly excurrent; seta single, yellowish to darker, ½ in. long; sporangium erect, cylindrical, actinomorphic or slightly arcuate, brownish. Autumn. Non-calcareous rocks in moist woods. Clarke, Fairfield, Lake.

10. DICRANODÓNTIUM Br. & Sch.

Slender, cespitose, bright green mosses, densely radiculose below; scales somewhat distant, long, soft and silky; seta single, very slender; sporangium erect, cylindrical; hypophysis tapering; operculum with inclined beak almost as long as the sporangium; peristome inserted below the sporangium mouth, teeth cleft, striate; calyptra cucullate.

Dicranodontium longiróstre (Starke) Br. & Sch. (*Didymon longirostre* Starke; *Didymon denudatus* Lindb.). Scales long-subulate, caniculate, costa excurrent, entire, faintly toothed near the apex; seta curved; peristome red. Fall and winter. Usually on rocks. Fairfield Co.

11. BROTHÈRA C. Muell.

Densely cespitose, pale green, radiculose; scales erect-spreading, linear-lanceolate, subulate, almost entire, costa broad, filling the outer part of the leaf, abortive scales forming tufts in the axils of the upper scales; seta erect or slightly curved; sporangium smooth, erect; peristome teeth divided to near the base; calyptra large, cucullate, fringed at the base.

Brothera leàna (Sull.) C. Muell. (*Campylopus leanus* Sull.). Small mosses up to ⅓ in. tall, rarely branched; seta less than ⅓ in. long; sporangium oblong to elliptical, not stomate. No definite reports can be found of this species although R. S. Williams, Sullivant, and Lesquereux include Ohio in its range.

TORTULACEÆ.

Small to medium-sized, cespitose mosses; scales dense with a hyaline or colored base; sporangium erect or rarely inclined, actinomorphic or slightly curved; peristome usually of 16 deeply-divided teeth, sometimes wanting.

1\. Scales widest in the lower half, usually acute 2
1\. Scales widest in the outer half, obtuse, costa excurrent 9
2\. Plants minute, cleistocarpous 3
2\. Plants larger, with a lid 4
3\. Margins strongly involute .... *Astomum*
3\. Margins slightly revolute .... *Phascum*
4\. Scales revolute, basal cells rarely hyaline, usually reddish or yellowish 5
4\. Scales plane or involute, basal cells mostly hyaline 6
5\. Peristome of 16 teeth, not twisted to the right, cleft .... *Didymodon*
5\. Peristome of 32 teeth, strongly twisted to the left, filiform .... *Barbula*
6\. Scale margins plane, peristome none .... *Gymnostomum*
6\. Scale margins involute, at least above 7
7\. Peristome none, operculum deciduous, attached to the columnella, *Hymenostylum*
7\. Peristome present 8
8\. Margins strongly involute .... *Weisia*
8\. Margins plane, or involute only above .... *Tortella*
9\. Peristome wanting .... *Pottia*
9\. Peristome present, but may be very short 10
10\. Peristome teeth 16, somewhat cleft; costa not excurrent, except in *D. plinthobius* .... *Desmatodon*
10\. Peristome teeth 32; costa strongly excurrent .... *Tortula*

1. ÁSTOMUM Hampe.

Small, dull-green mosses; scales dense, lanceolate, entire, costa percurrent, or excurrent; sporangium usually immersed; calyptra cucullate.

1. Scales distinctly crisped when dry; sporangium globose, or subglobose..... 2
1. Scales scarcely crisped when dry; sporangium ovoid............*A. nitidulum*
2. Branched, ¼–½ in. tall; sporangium globose, brown..............*A. crispum*
2. Usually simple, smaller; sporangium sub-globose, orange........*A. sullivantii*

Astomum críspum (Hedw.) Hampe. (*Weisia crispa* Mitt.; *Phascum crispum* Hedw.; *Systegium crispum* Schimp). Densely gregareous; lower scales smaller than the upper ones, linear-lanceolate, costa excurrent, papillose; seta shorter than the sporangium. Spring. Old fields. Not reported.

Astomum sullivántii Schimp. (*Systegium sullivantii* Jaeg.). Densely cespitose, dark green, erect. Autumn to early spring. Old fields. "Ohio" by Lesquereux.

Astomum nitídulum Schimp. (*Systegium nitidulum* Jaeg.; *Phascum nitidulum* Muell.). A small rare species, differing from A. sullivantii mainly in smaller and having shorter scales, rarely crisped when dry; seta about ⅔ as long as the sporangium; lid obliquely rostrate. Reported from Ohio in H. C. Beardsley's catalog.

Astomum nitidulum var. *pygmaeum* Lesq. Minute, much branched; costa percurrent; sporangium orange, lid straight rostrate. Reported from "Central Ohio" in Mosses of Ohio, Lesquereux and James.

(These last two may both be variations of A. sullivantii, according to both Jennings and Grout).

2. PHÁSCUM (L.) Schreb.

Small mosses; ours with entire scales, papillose, ovate to lanceolate, costa excurrent in the uppermost; sporangium immersed or slightly excurrent.

Phascum cuspidàtum (Schreb.) Hedw. (*P. acaulon* L.). Simple or sparingly branched, ⅛–³⁄₁₆ in. tall; upper scales crowded, lanceolate, acuminate, carinate-concave, margins revolute, costa excurrent; lower ones more distant, spreading, hyaline, papillose dorsally; sporangium globose, immersed, reddish-brown; seta erect or curved. Spring. On waste ground and fields. No definite reports, although Beardsley reports it as common.

3. PÓTTIA Ehrh.

Small simple mosses; scales broad; tufted above, carinate or deeply concave, papillose; seta erect, sporangium oval or cylindrical.

Pottia truncàta (Hedw.) Fuern. (*P. truncatula* Lindb.; *Gymnostomum trucatum* Hedw.). About ¼ in. tall, radiculose at the base; margins plane, crisped when dry, acute, costa distinct; seta ¼–½ in. long, yellowish; sporangium erect, actinomorphic, brownish; lid somewhat flattened. Autumn to spring. On wet soil. Reported from Ohio in Morgan's Flora.

4. WEÌSIA Hedw.

Small mosses with erect gametophores; scales erect-spreading, crisped when dry, elongate-lanceolate, upper larger than the lower, costa distinct, excurrent in a short point, upper surface papillose; seta long, usually erect; peristome small, teeth undivided, papillose.

Weisia virduíla (L.) Hedw. (*Bryum viridulum* L.; *Mollia viridula* Hedw.). Dense, yellowish-green, about 1/16 in .tall; upper scales tapering gradually to an acute or acuminate point; seta ¼–½ in. long, slender, yellowish; sporangium erect, ovoid, reddish-brown, grooved when dry; lid conic, obliquely-rostrate; spores orange, papillose. Spring. On bare soil. Clarke, Lawrence, Montgomery.

Weisia viridula var. *gymnostomoides* (Brid.) Braith. (*Hymenostomum microstomum* Aust.). Scales shorter and broader than in the preceding, peristome teeth short and truncate, lid with a shorter point. Reported from Ohio by H. C. Beardsley.

5. GYMNÓSTOMUM Hedw.

Unisexual, reddish-brown below, sparingly radiculose; scales tufted and larger at the top, erect-spreading, not crisped when dry, margins plane, costa ending below the apex, seta erect, long; sporangium actinomorphic, operculum early deciduous, calyptra cucullate.

1. Scales obtuse, ligulate . . . . *G. calcareum*
1. Scales acute or subacute . . . . *G. rupestre*

Gymnostomum calcàreum Nees. & Hornsch. (*Mollia calcarea* Lindb.). Dense, erect, branched, about ⅛ in. tall, yellowish-green; scales spreading, recurved, concave, obtuse; sporangium oblong, yellowish-brown, hypophysis tapering; rostrum oblique. On limestone rocks. Summer. Lake Co.

Gymnostomum rupêstre Schwang. (*Mollia aeruginosa* (Sw.) Lindb.). Larger than the preceding and not so densely cespitose; scales linear-lanceolate; sporangium ovate-oblong to sub-globose, yellowish or reddish-brown, seta reddish. Summer. On limestone. Lake Co.

6. HYMENOSTYLIUM Brid.

Densely cespitose, sparingly radiculose; scales dense, erect-spreading, not crisped when dry, but sometimes twisted, lanceolate, acuminate; seta erect, long; sporangium actinomorphic, operculum remaining attached to the columnella; lid oblique-rostrate; calyptra cucullate.

Hymenostylium curviróstre (Ehrh.) Lindb. (*Gymnostomum curvirostre* Hedw.; *Weisia curvirostris* Muell.). Light, bright green, fragile, 1 in. or more tall; scale bases sub-clasping, margins entire, recurved, cells papillose; seta ¼–½ in. long, castaneous; sporangium ovate, castaneous; spores yellowish. Late summer. Wet and usually calcareous rocks. Clarke, Lake.

7. DIDYMODON Hedw.

Mostly slender mosses; scales dense, lanceolate, scarcely crisped when dry, margins revolute, costa strong; sporangium erect, smooth, peristome of 16 teeth; operculum conic-rostrate; calyptra cucullate.

1. Lower portion of the plant reddish; scales acute or long sub-obtuse, *D. recurvirostre*
1. Lower portion of the plant brown; upper scales short and obtuse..*D. tophaceus*

Didymodon recurvirôstre (Dicks.) Jenn. (*D. rubellus* Br. & Sch.; *Barbula rubella* Mitt.; *Weisia recurvirostre* Hedw.). Densely cespitose, branched, about ½ in. tall, red below; scales spreading, costa sometimes excurrent in a short point, upper scales papillose, basal ones almost transparent; seta red, about ½ in. long; sporangium cylindrical-oblong; peristome reddish, teeth filiform. Late summer and autumn. Moist stones. Champaign, Clarke.

Didymodon tophàceus (Brid.) Jur. (*Trichostomum tophaceum* Brid.; *Barbula longifolia* (Dicks.) Lindb.; *Barbula tophaceæ* Mitt.). Branching, about ½ in. tall, brown below; scales spreading, a tuft of short, blunt scales at the tip, costa never excurrent; seta erect, slender; sporangium oblong-ovate. Limestone soil.

8. TORTÊLLA (C. Muell.) Limp.

Densely cespitose, yellowish-green, brownish radiculose below; scales spreading to recurved, crisped when dry, elongate to linear-lanceolate, margins involute to plane, entire, undulate, costa ending at the apex or excurrent; seta red, erect; peristome of 32 teeth, sinistrorsely wound, papillose; calyptra cucullate.

1. Scales abruptly mucronate with excurrent costa, hermaphroditic..*T. humilis*
1. Scales long-acuminate; unisexual.. 2
2. Scales straight, rather rigid, mostly broken......................*T. fragilis*
2. Scales twisted, crisped when dry, less fragile....................*T. tortuosa*

Tortella hùmilis (Hedw.) Jenn. (*T. caespitosa* (Schwaeg.) Limp.; *Tortula caespitosa* Hook. & Grev.; *Tortula humilis* Brid.; *Bryum humilis* Hedw.). Loosely cespitose, branched, ⅛–¼ in. tall; scales oblong to linear-lanceolate, margins plane or slightly undulate, erect-spreading, costa excurrent, cuspidate, a triangular patch of hyaline cells at the base; seta copper-colored, erect, ½–¾ in. long; hypophysis tapering; lid long-rostrate; calyptra cucullate; peristome single of 32 teeth, filiform. Summer. On soil and bases of trees. Champaign, Franklin, Lake.

Tortella tortuòsa (L.) Limp. (*Barbula tortosa* Web.f. & Mohr.; *Tortula tortosa* Ehrh.). Branched, green above; scales crowded near the apex, linear-lanceclate, spreading, tapering, long-acuminate, costa excurrent; seta reddish to paler above; sporangium cylindric, lid long-rostrate, oblique. On rocks. Not reported.

Tortella frâgilis (Drumm.) Limp. Similar to the preceding, but smaller and more slender; scales long-acuminate, slender, and the tips of all except the youngest usually broken off. Summer. Not reported.

9. BĂRBULA Hedw.

Yellowish-green to brownish, forked; scales erect-spreading, linear-lanceolate, margins mostly revolute, costate, basal cells colored; seta erect; peristome sometimes rudimentary or none, teeth 32, filiform, dextrorsely twisted; operculum conic-rostrate; calyptra cucullate.

1. Scales gradually tapering to an acuminate point, brownish-green. . *B. acuminata*
1. Scales obtuse, not tapering gradually; often mucronate, yellowish-green. . . . 2
2. Perichaetial scales sheathing, convolute. . . . . *B. convoluta*
2. Perichaetial scales not differing perceptibly from the others. . . . *B. unguiculata*

Barbula acumināta Hedw. (*B. fallax* Hedw.). Loosely cespitose, brownish often reddish, fastigially branched, ½–2 in. tall; scales rather distant, spreading to recurved, margins revolute to beyond the middle, entire, costa strong, ending below the apex, perichaetial scales sheathing at the base; seta erect, slender, red; sporangium oblong-cylindric; operculum long-rostrate. Late fall to spring. Soil and rocks in limestone regions. Lake, Montgomery.

Barbula convolūta (Huds.) Hedw. Densely cespitose, branching, ⅛–1 in. tall; scales erect-spreading, crisped when dry, oblong to linear-lanceolate, concave, margins crenulate, costa strong, usually ending below the apex, sometimes minutely excurrent; seta light yellow to reddish; sporangium erect, reddish-brown, narrow oblong-cylindric. Spring. On soil in limestone regions. Reported from Ohio by Lesquereux.

Barbula ungulāta (Huds.) Hedw. Densely cespitose, branching, ½–1 in. tall; scales erect-spreading or somewhat recurved, spirally twisted when dry, oblong-lanceolate, mucronate, costa strong, basal cells yellowish-pellucid to hyaline; seta erect, ½–1 in. long, red, slender; sporangium erect, oblong-cylindric. Late fall to spring. On soil and rocks. Fairfield, Lake, Montgomery.

10. DESMĀTODON Brid.

Small, slender, branched mosses; scales papillose; seta erect, elongated; sporangium erect, cylindrical; peristome irregularly cleft, short basal membrane very inconspicuous; lid long-rostrate, thick, oblique; calyptra cucullate.

1. Scale margins plane, bordered by light cells. . . . . *D. porteri*
1. Scale margins recurved. 2
2. Costa excurrent in a long, smooth arista. . . . . *D. arenaceus*
2. Costa not excurrent, scales mucronate. . . . . *D. plinthobius*

Desmatodon oblongifōlius Schwaeg. (*D. arenaceus* Sull.; *D. ohioensis* Schimp.; *Didymodon arenaceus* Lindb.). Gregareous, yellowish-green, radiculose at the base; scales tufted at the top, erect-spreading, crisped when dry, blunt, costa strong, margin crenulate, upper cells papillose; seta castaneous; sporangium dark-castaneous; peristome yellowish to reddish, teeth split to near the middle only. Spring. Sandy soil and rocks. Fairfield.

Desmatodon plinthòbius Sull. & Lesq. (*Tortula plinthobius* (Sull. Broth.; *Barbula subcarnifolia* C. Muell. & Lindb.). Scales obtuse, costa strong, arista as long as the remainder of the scale; sporophyte similar to the preceding genus; sporangium oblong to nearly cylindrical, peristome minute, pale. Rocks. Fairfield.

Desmatodon pórteri James (*Tortula porteri* (Jas. & Aust.) Broth.). Minute mosses; scales brownish-green, tapering, bluntly acute; sporangium oblong, erect, teeth divided nearly to the base; seta orange. Spring. On rocks. Clarke.

11. TÓRTULA Hedw.

Robust plants, green to brown; scales oblong, larger near the tip of the gametophores, costa strong; sporangium cyclindrical, peristome of 32 teeth, twisted towards the left, papillose; operculum conic, oblique-rostrate; calyptra cucullate, covering half of the sporangium.

1. Cells of the scales smooth, awn smooth........................*T. mucronifolia*
1. Cells of the scales papillose, awn rough, hyaline at the tip, colored below..*T. ruralis*

Tortula ruràlis (L.) Ehrh. (*Bryum rurale* L.; *Barbula ruralis* Hedw.). Loosely cespitose, light green above, brown below, 1–2 in. tall; scales dense at the apex of the stalk, more distant below, recurved-squarrose when moist, appressed when dry, entire, reflexed, costa excurrent into the rough awn; peristome teeth long, membrane ½ the height of the peristome; seta reddish at the base, lighter above. Spring. On rocks and sterile soil. Erie Co.

Tortula mucronifòlia Schwaeg. (*Barbula mucronifolia* Br. & Sch.). Loosely cespitose; scales ovate to oblong, reflexed, costa excurrent into a smooth point; sporangium ovoid-cylindrical; basal membrane almost as long as the teeth; operculum conic, elongated. Summer. Reported by Lesquereux.

LEUCOBRYACEÆ.

Dense tufts of whitish to glaucous-green mosses, spongy when moist, brittle when dry; scales of three layers of cells, tubular above, costa covering most of the scale; operculum conic-rostrate; calyptra cucullate.

1. LEUCOBRYUM Hampe.

Unisexual; scales crowded; sporangium more or less arcuate, strumose, 8-striate; peristome of 16 teeth or of 8 teeth divided almost to the base, united at the base into a tube.

1. Scales large, tufts 2 in. or more deep; sporangium arcuate, strumose, *L. glaucum*
1. Scales small; tufts ½–¾ in. deep; sporangium nearly erect, and slightly or not at all strumose..*L. albidum*

Leucobryum glaùcum (L.) Schimp. (*L. vulgare* Hampe.; *Dicranum glaucum* Hedw.). Scales bristle-tipped, wide and clasping at the base, outer part rolled; seta erect, single, castaneous, sporangium decidedly arcuate and striate, distinctly strumose. Autumn. In moist woods on rocks and soil. Champaign, Fairfield, Fulton, Holmes, Lake, Portage, Seneca, Stark.

Leucobryum álbidum (Brid.) Lindb. (*L. minus* Hampe; *Dicranum albidum* Brid.). A smaller species which Dixon describes as a subspecies of L. glaucum; scales more crowded, with the tubular portion of the scale scarcely as long or often much shorter than the ovate base. Late spring and early summer. On wood or soil. Champaign, Fairfield, Lawrence, Sandusky.

ENCALYPTACEÆ.

Cespitose branched mosses, bright green above, brown radiculose below; scales dense, bordered, twisted when dry, costa strong, dorsally papillose and toothed, basal cells hyaline or colored, smooth, upper cells papillose; seta erect, slender; sporangium cylindric, actinomorphic; calyptra completely enclosing the sporangium.

1. ENCALYPTA Schreb. Hedw.

Only one species of this family has been reported from Ohio.

Encalypta ciliàta Hoffm. (*Leersia ciliata* Hedw.; *Leersia laciniata* Hedw.). Loosely cespitose, about 1 in. tall; scales apiculate, margins plane above, recurved below, costa excurrent or ending near the apex; calyptra fringed with narrow lanceolate teeth; peristome of 16 teeth; autoicous. Late summer or fall. Reported from Ohio by Lesquereux.

FISSIDENTACEÆ.

Minute to large mosses, gregareous or cespitose, light to dark green, reddish radiculose below; scales 2-ranked, vertically placed, the base sheathing, with an often decurrent dorsal lamina, usually costate, cells rounded-hexagonal; seta erect or curved; peristome, when present, red and simple, teeth usually cleft; calyptra conical, smooth.

1. Dorsal laminæ narrow; stalk bulbiform at the base; peristome wanting, *Bryoxiphium*
1. Dorsal laminæ usually wider; stalk not bulbiform at the base; peristome present.......... 2
2. Terrestial or submerged, not floating.......... *Fissidens*
2. Aquatic, floating, filiform.......... *Octodiceras*

1. BRYOXÍPHIUM Mitt. (Eustachia Brid.).

Gregareous, flat, usually simple mosses; scales imbricated, linear-lanceolate, glossy, bordered, costa percurrent, perichaetial scales long-acuminate; calyptra cucullate; unisexual.

Bryoxiphium norvegicum (Brid.) Mitt. "Sword Moss." Yellowish, ⅓–1 in. tall; scales short-acuminate; sporangium obovate, yellow, red at the mouth, inclined; seta thick; operculum red at the base, persistent; peristome none. Shaded vertical sandstone faces. Fairfield Co.

2. FÍSSIDENS Hedw.

Simple or sparingly branched mosses; scales strongly winged, linear-obovate to lance-obovate; antheridia in gemmiform buds; annulus narrow, teeth cleft; calyptra cucullate.

1.	Scales not bordered	2
1.	Scales bordered	5
2.	Costa excurrent in an apiculus	*F. taxifolius*
2.	Costa ending at or below the apex	3
3.	Scales entire, apex obtuse	*F. obtusifolius*
3.	Scales serrulate or crenulate	4
4.	Scales apiculate; seta terminal; costa to near the apex	*F. osmundoides*
4.	Scales more rounded; seta lateral; costa ending some distance below the apex	*F. subbasilaris*
5.	Costa none; very small mosses	*F. hyalimus*
5.	Costa distinct	6
6.	Border only on sheath	*F. exiguus*
6.	Border quite or nearly to the apex	7
7.	Border of narrow elongated cells; costa to the apex	8
7.	Border of paler cells of the same shape as the others; costa ending below the apex	9
8.	Border confluent with the costa, forming a blunt point	*F. bryoides*
8.	Border very narrow, almost disappearing below the apex	*F. incurvus*
9.	Plants less than ¾ in. tall; cells indistinct	*F. cristatus*
9.	Plants ¾–4 in. tall; cells of the scales distinct	*F. adiantoides*

Fissidens taxifòlius (L.) Hedw. (*Hypnum taxifolius* L.). Light green, branching at the base, less than ½ in. tall; scales crowded, oblong-ovate, obtuse, crenulate, costa strong; seta lateral, flexuous, reddish, sporangium usually curved, inclined or pendulous, oblong, brown; teeth cleft to below the middle. Late fall and winter. On moist soil in woods. Champaign, Clarke.

Fissidens hyalìnus Wils. & Hook. Minute, pale simple mosses; scales in 3–5 pairs, oblong-lanceolate, acute, entire; seta terminal, erect; sporangium oblong, erect or oblique; operculum rostrate, calyptra covering the beak. Clay banks and rocky ledges. Rare. Hamilton, Lake.

Fissidens bryoìdes (L.) Hedw. (*Hypnum bryoides* L.). To ¼ in. tall; scales oblong, entire, costa strong; antheridia in axillary pediculate buds; seta terminal, erect, slender, copper-colored, less than ½ in. long; sporangium erect, short, oblong-oval; teeth split ⅔ their length. Late fall. Shaded pots in the greenhouse. Franklin, Lake.

Fissidens obtusifòlius Wils. Minute, erect, simple mosses; scales entire, oblong, upper ones ascending, cells rounded, costa ending below the apex; seta erect, brownish; sporangium erect, oblong-ovate, brownish; operculum very short-rostrate; peristome yellowish-pellucid. Autumn. Wet rocks. Clarke, Fairfield, Hamilton.

Fissidens incúrvus (Starke) Schw. Simple mosses, ¼–½ in. tall; scales oblong-lanceolate, apiculate, or bordered to near the apex; seta reddish, ¼–¾ in. long; sporangium ovoid, cylindrical, curved; antheridia in basal buds. Late autumn. On rocks. Clarke Co.

Fissidens incurvus var. *minutulus* (Sull.) Aust. (*F. minutulus* Sull.). Minute, green erect, simple; scales in 3–7 pairs, narrowly oblong-lanceolate, margin entire or undulate, costa ending below the apex; seta reddish; sporangium usually actinomorphic and erect. Autumn. Damp rocks in the shade. Clarke, Franklin, Hamilton, Lake, Perry.

Fissidens exíguus Sull. (*F. incurvus* var. *exiguus* Aust.). Light green, very small; scales in 3–5 pairs, upper ones the largest, dorsal laminæ narrowing to none at the base, costa ending below the apex; sporangium erect or inclined, oblong-oval, reddish-yellow. Early fall. Rocks in ravines and streams. Franklin Co.

Fissidens cristàtus Wils. (*F. decipiens* DeNot). Slender mosses, branching at the base, ½–1 in. tall; scales numerous, imbricated, ovate-lanceolate, laminæ somewhat decurrent; seta lateral, brown; sporangium oblong, tapering, constricted below the mouth, nearly erect, golden-brown; teeth cleft into very narrow divisions. Winter and early spring. Soil, stones, or bases of trees. Champaign, Franklin, Muskingum.

Fissidens adiantoìdes (L.) Hedw. (*Hypnum adiantoides* L.). Light green, slender, branching; scales serrate, oblong-lanceolate, border often indistinct, laminæ ending abruptly at the base; seta lateral, reddish-brown, flexuous, ½–1 in. long; sporangium horizontal to erect; antheridia axillary. Winter. Clay soil, rocks, and bases of trees. Champaign, Clarke, Franklin, Lawrence.

Fissidens osmundoìdes (Swartz.) Hedw. (*Dicranum osmondoides* Swartz). Dark green, erect, branched, tomentose below; scales oblong-lanceolate obtuse, apiculate, serrulate near the tip, non-bordered, laminæ not decurrent, costa to near the tip; seta terminal, reddish-brown, ¼–½ in. long; sporangium darker, horizontal or inclined, mouth wide, hypophysis tapering; operculum with a long straight beak. Summer. On ground or tree trunks in swamps. Champaign Co.

Fissidens subbasilàris Hedw. Green, with a brown tomentum below, ¼–¾ in. tall; scales oblong, obtuse, apiculate, serrulate near the apex, costa ending some distance below the apex, laminæ large, rounded at the base; seta lateral, yellowish-brown, reaching to the top of the gametophore; sporangium oblong-cylindrical, nearly erect, smooth, brown, hypophysis tapering; peristome darker, teeth cleft to the middle, points slender; operculum with an oblique point half the length of the sporangium. Late autumn. Trees and rocks. Champaign, Clarke.

3. OCTODÎCERAS Brid. (*Concomitrum* Mont.).

Slender, floating, branched mosses; scales distant, linear-lanceolate; seta short; sporangium small; calyptra mitrate, operculum conic-rostrate.

1. Much branched, 2–6 in. long . . . . *O. debilis*
1. Sparingly branched, less than ½ in. long . . . . *O. hallianus*

Octodiceras debilis (Schw.) Jenn. (*O. julianus* Brid.; *Concomitrum julianum* Mont.; *Fontinalis juliana* Savi.; *Fissidens julianus* Schimp). Flaccid, blackish-green below; scales long, spreading, non-bordered, inferior laminæ not reaching the base, costa vanishing below the apex; seta fragile, shorter than the sporangium; teeth degenerate. In streams and swamps on wood and stones. Summer. Reported from Ohio by Lesquereux.

Octodiceras halliànus (Sull. & Lesq.) Jaeg. & Sauer. (*Concomitrium hallianum* Sull. & Lesq.; *Fissidens hallianus* Mitt.). Dark green, in loose, floating tufts; scales narrowly linear, entire; seta longer than the sporangium; sporangium obovate, pale; teeth not divided; calyptra cucullate. On partially submerged wood and stones in streams and swamps. Not yet reported.

BIONOMIC NOTES ON SOME PARASITES OF ACHATODES ZEÆ HARRIS (NOCTUIDÆ, LEP.) AND PHLYCTAENIA TERTIALIS (GUEN.) (PYRALIDÆ, LEP.).

W. V. BALDUF.*

Beyond the mere description of species nothing has been written concerning most of the parasites of the elder borer (*Achatodes zeæ* Harris) and the elder leaf tier (*Phlyctaenia tertialis* (Guen.). The present article is an account of observations made at Oak Harbor, Ohio, and Urbana, Illinois in 1927 and 1928, on the parasites reared from the above Lepidoptera. One or more individuals of most species developed under the direct observation of the writer, hence no doubt remains regarding the hosts to such forms. As for the other species no other insects except these moths were present in sufficient numbers to have been the hosts of the parasites reared miscellaneously from elder.

PARASITES FROM *Achatodes zeæ*.

The elder borer is a conspicuous white Noctuid larva with black tubercles. It is common in succulent elder (*Sambucus*) stems from May to July. When full-grown, the larva forsakes its old burrow and bores anew into dry stems of elder or large weeds. Pupation occurs there chiefly during June and July, and the adult issues through exits prepared in the side of the stems by the larva. The flattened disc-shaped eggs are inserted under the edges of partially loose bark on old elder stems from middle to late summer. The species winters in the egg stage, and the young larvæ probably hatch early in May at Urbana. Any parasites attacking the egg, larva, or pupa need to penetrate more or less woody tissue of the elder to reach the host.

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Parasites have been reared to date only from the larval and pupal stages of the borer, and all were species of Ichneumonoidea and Chalcidoidea. The larval stage is attacked by the larger number of these.

HYMENOPTERA.

Microplitis gortynæ Riley.

Microplitis gortynæ Riley, Vipionidæ, a species about 2.5 mm. long with a black body and yellowish-brown legs, is the most abundant parasite attacking the elder borer, and was also reared from the common stalk borer (*Papaipema nitela*) by Dr. C. R. Neiswander at Oak Harbor. The specimens described by Riley (1) were reared from cocoons from *Achatodes* (*Gortyna*) *zeæ* received by him from Dr. Hoffmeister in Iowa. Its habits are similar on both hosts. The parasite lives internally in the host. While emerging, the mature larva secured leverage on the inside structures of the host or on the bodies of its cohabitants. That such leverage is useful is indicated by the failure, in some instances noted, of the last one or more of the larvæ to escape when the body of the caterpillar has become flabbid due to the issuance of most of the parasites. Passage through the muscles of the host is affected by pushing and gyrating with the head applied to the body wall of the host, but the outer chitinous layer is penetrated and torn by the action of the extended mandibles and maxillæ.

The newly emerged larvæ remain attached to the host by means of the posterior bulb-like process on the abdomen that is left inserted in the exit hole and is distinguished from the rest of the body by a definite constriction. Distribution of a mass of larvæ from one host is quite general over the abdominal and posterior thoracic regions, and chiefly on the dorsal and lateral aspects. Being contiguous during cocoon-spinning, the individual cocoons of a mass become more or less inter-twined, but some are isolated. The host is usually overcome by the emerging parasites shortly before it would have left its first burrow to enter the characteristic place for pupation. This fact is confirmed by Hawley (2) who says "the larva of the parasite apparently leaves the grub (*Gortyna immanis*) just as the latter is about to pupate." Hence, there is only enough space between the caterpillar and the walls of its burrow to accomodate the cocoons of the parasites.

In making the cocoons, the larvæ stand out perpendicular to the host. The strands of silk from the pair of labial pores are not always fully united before they become hardened from exposure, and then form a broad flat line. At first a jumble of silk is formed by the larva around its cauda. On this basis, the larva produces series of small loops, row upon row, much as a stocking is knit, and with considerable industry as indicated by loops formed at the rate of 43 per minute, in one instance. Fresh silk strands applied to the bare body of a neighboring larva fail to adhere. The inner, continuous layer of the cocoon is made after the larva relinquishes its hold on the host. The cocoon is of the type commonly described as ribbed, the ribs consisting of longitudinal, more or less parallel, rounded external ridges of silk, When the continuous layer of the cocoon is begun, the larva engages chiefly in vibrations lengthwise, and concentrates on rather definite spaces which therefore receive more silk than the intervals between the ribs. These thinner intervals are built up by rapid, short transverse brushings of the face on these areas. The ribs thus develop due to a preponderance of time and material given to these alternate spaces, which also appear as convexities on the outer surface on account of the pressure outward by the larva during the spinning process.

Emergence of the larvæ was observed at Oak Harbor in 1927 on June 24 and 25 from *A. zeæ*, and on Aug. 9 from *P. nitela*. In 1928 the first cocoons at Oak Harbor were found on June 29, and larvæ in the act of spinning were discovered occasionally during the next two weeks. Of 206 *A. zeæ* caged, 23, or 11.16% were parasitized by *M. gortynæ*. The number of cocoons per individual host ranged from 10 to 39, but the majority bore 26 to 32, and the average for all was 25.3 per borer. Of 65 Urbana caterpillars, only one was killed by this species, 23 cocoons being present in this case. Hawley (2) found 80 cocoons "with a single skin" of *Gortyna immanis*. The borer above that yielded only 10 parasites was found to have left its original burrow and had formed its pupal cell before it was overcome. This seems to indicate the effect of difference in number of parasites on the vigor of the host. Usually the host is killed in its original tunnel.

New cocoons of *M. gortynæ* obtained from *A zeæ* in June and July of 1927 and dissected in September and February, show that the species winters as a larva in its cocoon and that

only one generation develops in a year. Some of the cocoons kept in a warm laboratory yielded adults in March (1928), whereas others obtained by Dr. C. R. Neiswander of Ohio from *Papaipema nitela* in August (1927) and kept in an outdoor insectary at Oak Harbor, produced adults in June (1928), a few being alive on June 29. Hawley (2) found adults coming from their cocoons in the field in New York on June 11, 1915, and in the laboratory observed them parasitizing "partly grown larvæ" of *Gortyna immanis* Gn. at that time." And later in the summer the cocoons were again found (Hawley) both in the cages and in the field." Henry Bird (3) reports this parasite attacking also *Papaipema nebris* Guen. at Rye, N. Y.

The four hosts cited above,—*A. zeæ*, *G. immanis*, *P. nitela* and *P. nebris* are closely related forms of Noctuidæ and have similar life cycles which favor the attack of *M. gortynæ*, both hosts and parasite having one generation per year, and their larval stages run parallel during June and July. According to the writer's observations in Ohio, the first adult parasites to issue find *A. zeæ*, whereas later comers have the larvæ of *P. nitela* available for their progeny, the latter species of host appearing in the larval state one to several weeks later than *A. zeæ*.

Microbracon lutus (Prov.) (*lixi* Ashmead).

Provancher's (4) original description gives no bionomic data for this Braconid, and later records concerning it are few. These are condensed from Musesbeck's summary (20) as follows: "Bred from *Lixus scrobicollis* Boh. on *Ambrosia trifida*" by Dr. A. D. Hopkins; *Papaipema nebris* Gr. (H. Bird, Rye, N. Y.); two reared from *Ambrosia* at Manchester, Mass., by the U. S. Bureau of Entomology European Corn Borer Laboratory. All are females. He adds that "but little material of this species in addition to the types, has been seen." The adult is 3.5 to 4.0 mm. long, with color yellowish-brown, and antennæ, propodeum and tarsi darker. The mature larva dissected from its cocoon in the winter is 3.5 mm. long and 2 mm. wide at the middle, depressed, more nearly flat below than above, and ovate in outline with ends broadly rounded. The head is small and the mouthparts reduced in the usual manner of Ichneumonoidea. The abdominal segments, ten in number, are mostly longer than the thoracic segments. The

color is bright lemon-yellow. The cocoons have a slightly convex surface when massed together, but when occurring singly, or by twos or threes, are more strongly convex. In outline they are somewhat irregular, but roughly elongate-oval, and when in masses conform to the shape of the surroundings. Their deep-brown color renders them inconspicuous in the dark-walled burrows of their hosts. One entire mass of 13 cocoons is one inch long. When only a few are present they may be isolated.

Six adults reared from cocoons obtained from Paris, Illinois, were five females and one male. A dead male was removed from its cocoon at Oak Harbor in June 1927. In the summers of 1927 and 1928 in Ohio, masses of empty cocoons were discovered occasionally, always in the deserted burrows of *A. zeæ*.

The immature larvæ have been found to be ectoparasitic on advanced caterpillars of *A. zeæ*. They were first seen on June 27, 1927 at Oak Harbor when three individuals occurred feeding on an almost full-grown host. On June 29, two of these were each just over 2 mm. long, whereas the third measured 5 mm. in length and 1.5 mm. in maximum diameter. The bodies of these, and of all others of this species taken subsequently on this host, bore polka dot-like spots, perhaps subskeletal fat specks, on the body. These persisted until after the cocoons were spun, but had disappeared by midwinter. The larvæ are fairly agile, occur here and there on the host, and promptly crawl under cover when exposed to the light. The larvæ insert their mandibles into the host's exoskeleton and appear to suck liquids for food. At times, upon seizing the host with the madibles and pulling vigorously, the hold was suddenly broken, causing the parasite to snap back with a jerk. It is likely that a small hole is thus prepared to which the mouth is then probably applied in feeding. The parent parasite may paralyze the host at the time of oviposition, inasmuch as the hosts observed, even when the parasite larvæ were small, never travelled from where they were first seen. The present host seemed to be dead although decay failed to exhibit itself during five days of observation in partly very warm weather.

By June 30 these parasite larvæ had grown to 3.7 and 5 and ⅔ mm. long, respectively, and the host was very flabby, although still bright in color. The weather was hot and humid, and growth rapid. On July 1, the largest larva had spun its

cocoon, and the smaller larvæ had become mature, being 5 mm. long, and began to make their cocoons on that date. As an instance of superparasitism, it should be stated that this particular caterpillar was also parasitized internally by larvæ of *Microplitis gortynæ*, and by a dipterous maggot which at first worked externally, but spent most of the stage inside the borer feeding on the larvæ of *M. gortynæ* which failed to mature. The fly died in its puparium.

On June 30, 1928, another *A. zeæ* larva, 30 mm. long, or near maturity, was found parasitized externally by three larvæ of this species at Oak Harbor. Again there was a marked discrepancy in size among them. The host also retained its fresh white appearance while the parasites fed upon it, and although incapable of locomotion, was still alive. As in the above instance, this caterpillar was superparasitized, containing 20 larvæ of *M. gortynæ*, which, however, emerged and formed their cocoons on July 2. By this date the *Microbracon lutus* larvæ had grown to two or three times their size of June 30. Two made their cocoons on July 3 and the third on July 5, growth being very rapid.

At Urbana on May 30, 1928, an *A. zeæ* larva halfgrown was taken in elder and bore on its back a speckled external parasite then slightly more than 2 mm. long. It spun its cocoon on June 3 on several others of its kind about one inch, as in the three instances described above, from the now collapsed host. There was no evidence of superparasitism in this instance, and the dilapidated state of the host was probably caused chiefly by feeding of the several parasite individuals that had reached maturity on it before May 30. It was probably quite small when parasitized. According to this instance, *M. lutus* therefore began activity earlier by about a month at Urbana than at Oak Harbor.

These Oak Harbor and Urbana cocoons of 1928 still contained lemon-colored larvæ on December 31, 1928, when they were placed indoors and one of the adults issued under forced conditions in early February, 1929. Inasmuch as the mass of cocoons from Paris, Illinois also was occupied by such larvæ in February, it is obvious that *M. lutus* passes the winter in the larval state in its cocoons formed from latter May to early July at Urbana and Oak Harbor, respectively. Because the host is not in the larval condition until early May (Urbana) and late May or early June (Oak Harbor), and further because

the parasite larvæ attack advanced borers, it is clear that pupation and adult emergence of the parasite occur in May or June. The female possesses a robust ovipositor which, it may be inferred, penetrates the green succulent elder stems which at that time have tender walls rendered thin by the feeding of the larger borers probably present at the time of oviposition. There is thus only one generation in a year, which, like that of *Microplitis gortynæ*, coincides with that of their mutual host.

Epiurus pterophori (Ashmead).

One specimen of the Ichneumonid *Epiurus* (*Pimpla*) *pterophori* was reared from a burrow of *Achatodes zeæ* at Reno, Ohio, near Oak Harbor. This species, described by Ashmead in 1889 (5), had previously been reared in March by Mr. Albert Koebele from a *Pterophorus* (Pterophoridæ, Lepidoptera) living in stems of *Baccharis pilularis*, in Los Angeles, California. On June 21, 1928, the writer found in the hollow elder stem the much shrivelled remains of an *A. zeæ* caterpillar readily distinguishable by the spurs on the anal tergite. One inch from the dead host a partition of silk at right angles to the length of the burrow had been constructed by the parasite then still in the larval state. The other end of the cocoon consisted of the end of the host's tunnel. This cell, 16 mm. long and as wide as the burrow, was lightly faced on its whole area with silk that was scarcely visible. The host had been overcome while rather small, as indicated by the very short burrow it made before it was killed. The larva pupated on June 22. Development in the pupal state was retarded by six days of cool weather, but the adult condition was reached on July 2, or in a transformation period of 10 days. In escaping from its cell, the adult broke down most of the brown partition of silk at the end, but instead of crawling out in the burrow of the host and issuing to the outside through the exit of the borer, it prepared its own circular exit two mm. in diameter through the woody stem of the elder and close to its pupal chamber. This species probably has alternate hosts, and was obviously rare on the elder borer. The adult is almost 16 mm. long, including the ovipositor, and has a black body, while the legs are mostly shiny brown.

It was possible to study the larval and pupal stages of this insect carefully in life, hence descriptions of these are given herewith. The mature larva is 10 mm. long, with a maximum

width of 2.2 mm.; the body tapers to a blunt posterior and the 13 postcephalic segments are very distinct and quite uniform in length except the first longer and the last smaller. The color is yellowish-white, and the surface minutely and densely tuberculate. The top of the head has four longitudinal black bands, the outer members being strap-shaped and about five times wider than long; the middle two are triangular with their outer edges curved. The antennæ are minute, yet distinct, conical, and two-segmented, each segment ringed black at its base. On what seems to be the lower edge of the labrum is a transverse row of coarse black teeth, the lateral members very short, the mesal one the longest, with the intermediate two intermediate in size. The three larger teeth are thick, robust, rounded at the base and taper to a blunt tip. The mandibles are heavily chitinized, brown, forming a triangular figure arising at the sides of the labrum. The prothorax bears a pair of brown, almost crescent-shaped patches on its humeral angles. These are oblique, and extend cephalo-ventrad from the hind edges of the segment. The thorax bears one pair of spiracles on the front lateral edge of the middle segment. The abdomen has a pair of spiracles on each of the first eight somites, and are situated just above the lateral lobes at the anterior edge of the segment.

The newly transformed pupa is white, 11. mm. long, and 2 ⅓ mm. in maximum width which is at the thorax. The ovipositor arises from the venter of the sixth segment (not counting the propodeum or the petiole), and bends around the tip of the abdomen, and forward to the middle of the fourth abdominal segment, its entire length in contact with the body. This condition suggests that of the ovipositor in the adults of the chalcid family Leucospidæ. The second abdominal segment is longer than one, and three to seven. Each of segments two to six has two sharp pointed spurs on each side below the spiracles, one dorsad of the other, the lower one situated near the lower edge of the tergites. Segments five to seven also bear a transverse row of six shorter, finer spurs, three on each side of the dorsal part of the ovipositor. Arising from the hind edge of the last tergite and near the ovipositor are four much larger, heavier spurs, all directed slightly caudad. The head and thorax are lemon-yellow, but the abdomen is white like the larva, except the tip of the abdomen. The body is bare excepting the hairs or spurs already described, and the

propodeal furrow is margined with prominent, well-defined ridges rounded above and diverging slightly beyond the middle and more sharply thereafter.

Amblyteles spp.

Mr. Cushman identified eight specimens of *Amblyteles* as *A. scelestus* (Cress.), *A. consignatus* (Cress.), and *A. caeruleus* (Cress), and in his report (a letter of Sept. 24, 1928) adds, "Further study convinces me that these specimens represent one end of a very widely variable species, ranging from nearly black to brilliant blue or green and with great variation in sculpture." They vary in length from 11.5 mm. to 14 mm. The bionomic data obtained in the present writer's observations confirm Cushman's conclusion. All these species were reared from the chrysalis stage of *Achaodes zeæ*, and within the same season. The first adult found was removed fully formed from its host on May 11, 1928. Mr. E. G. Kelsheimer had collected the elder stem containing this individual at Paris, Illinois in mid-April, and the material had been kept indoors in the meantime. On May 10, 1928, the writer gathered eight entire pupæ of *A. zeæ* in old elder stems at Urbana, and from May 15 to 22, adults of these *Amblyteles* spp. issued indoors. In addition to these, two specimens were obtained from Oak Harbor pupæ of this moth, one on July 23, and another on July 26, 1928.

Considering the known facts about the life history of the host, it seems that *Amblyteles* spp. parasitize the nearly or quite mature borers. The host pupates in the usual place and is overcome by the parasite before the moth state is reached, the parasite possibly becoming a pupa before winter. These parasites seem therefore to have one generation annually adjusted to hosts with one cycle per year.

Cresson described *A.* (*Ichneumon*) *consignatus* (6) from one male taken at Ridings, W. Va.: *A.* (*Ichneumon*) *scelestus* (7) from Illinois, and *A.* (*Ichneumon*) *caeruleus* (7) from the eastern states. The writer's material was as follows: two *A. scelestus* from Oak Harbor, Ohio; and the rest of the material representing *A. consignatus* and *A. caeruleus* was obtained at Urbana, or at Paris, Illinois. Most of these are the latter form.

Eupteromalus viridescens (Walsh).

Mr. A. A. Girault (8) summarized the known host records of *Eupteromalus viridescens*, but his account perhaps contains

some confusion in host relations because this species and *Hypopteromalus tabacum* Fitch are regarded by him as one, whereas, Mr. A. B. Gahan (9) considers them distinct forms. However, it has always been reared as a hyperparasite, mostly from cocoons of *Apanteles* and their relatives. The writer had it quite commonly from the cocoons of *Microplitis gortynæ* Riley and *Microbracon lutus* (Prov.), both primary parasites of the elder border, *A. zeæ*. Harry Walker reared it from *M. gortynæ* cocoons on *Papaipema nitela* at Oak Harbor on June 25, 1928. In February 1928, the writer had it from *M. lutus* cocoons from Paris, Illinois, and dissected dead specimens from the same host at Oak Harbor in June 1928. As many as four dead individuals occurred in one cocoon. Holes through the thinner, lateral walls of the cocoons show that the hyperparasites sometimes pass from one cocoon to its neighbor, rather than penetrate the tougher outer cover. However, they can issue only through this upper cover, the other surfaces being in contact with the burrow of the borer. Exit holes found on August 30, 1928, in new cocoons made in June and July by both *M. gortynæ* and *M. lutus* were probably made by this species. In this lot was found one dead specimen of this hyperparasite with its ovipositor inserted into a cocoon of *M. gortynæ* in August. *E. viridescens* obviously goes through more than one cycle in a year. The adult is about 2 mm. long, the body is metallic black and green, and the legs yellowish-brown.

Miotropis clisiocampæ Ashm.

Old elder stems collected by E. G. Kelsheimer at Oak Harbor in December 1927, contained one dead chrysalis of *A. zeæ* occupied by *Miotropis clisiocampæ*. A single, small irregular hole in the side was obviously made by some emerged adults of this Eulophid (Chalcidoidea) parasite. The chrysalis, which occupied the usual position of this host in the old elder stem, still retained the dead bodies of 105 *M. clisiocampæ* in various states of development between pupa and adult. Some solid matter of the host remained. Because there is only one generation of *A. zeæ* annually, this individual host had been parasitized by *M. clisiocampæ* not later than June or July of 1927, and the parasites very likely issue normally sometime before winter from this host.

During the summer of 1928 two additional lots of this species came to hand at Oak Harbor from *A. zeæ*, presumably from two individuals of the host. On and about July 18, 145 parasites appeared in a cage containing only pupæ of this borer, and on or near August 20, 279 specimens were taken from another cage in which the same stage of this host was present. When these cages were discontinued, one pupa of *A. zeæ* was found to have a small emergence hole in its side and contained remnants of small chalcids. All the *M. clisiocampæ* obtained from the three chrysalises are females.

Mr. Gahan, in his report following the study of this parasite material, states that this Eulophid is "a common parasite upon various lepidopterous pupæ." Ashmead described it (20) from four female specimens bred June 28, 1891, by Prof. A. D. Hopkins from *Clisiocampa americana* on apple at Morgantown, W. Va. Doctor L. O. Howard (21) identified it from the same host and state, at Frenchcreek, where it had been reared by Mr. F. E. Brooks. Doctor A. L. Quaintance (22) cites Fiske (23) who obtained it from the pupa of the same moth in New Hampshire. Phillips, Underhill and Poos (24) had it from one pupa of *Diatraea zeacolella* Dyar which "yielded about thirty specimens" of this parasite. All of these issued through five emergence holes. The adults in alcohol measured 1.3 to 2 mm. in length. All are dark, polished, with the scutellum and metathorax light brown or yellowish, and the legs and part of the antennæ pale yellow. The dorsal outline of the abdomen (female) is almost round.

Habrocytus sp.

This Pteramalid species was taken in small numbers only from cages containing the pupæ of *A. zeæ* and the cocoons of *Microplitis gortynæ*. Both sexes were bred between August 23 and 28, 1928 at Oak Harbor. It resembles *E. viridescens* but is larger with darker legs, and the female abdomen tapers to a sharper point behind.

Eurytoma sp.

Two females of this species were taken alive in a cage of *A. zeæ* on July 11, 1928, at Oak Harbor. They are perhaps parasites, but their host in this case is unknown.

DIPTERA.

Aphiochaeta aletiæ (Comstock).

The remarkable habits of this Phorid have already been described by the writer (11)*. This fly is 2.5 mm. in length. The body is brown to black, and the legs vary in color from yellowish to deep brown. While dissecting old elder stems in February 1928, a dead *Achatodes zeæ* larva was discovered in its original feeding burrow, and one-half inch from the exit hole. The body had shrivelled and collapsed, and its black color indicated again that a plant disease caused its death. Chiefly within two inches of these caterpillar remains lay 73 empty puparia, which, judged by determined specimens of this stage, were positively those of *A. aletiæ*. The dried condition of the borer nevertheless made it possible to notice that the mandibles were widely spread apart, much as the anus of the specimen previously described (11) had been permanently distended. In another instance, two mature caterpillars of *A. zeæ*, from Urbana, which were killed and blackened by a fungous or bacterial disease bore mature but small maggots on their backs on July 9, 1928. The maggots compared structurally with those described heretofore (11), and were no doubt this species of Phoridæ. The present evidences therefore confirm those cited in the former article and show *A. aletiæ* to be a scavenger. The maggots appear habitually to feed internally in the *A. zeæ* larvæ, and seem not to enter by breaking the body wall but utilize the natural apertures, the anus or perhaps the oral opening, as places for entrance.

Because elder borers killed by this disease were abundant during the latter part of June and early July, 1928, it is probable that the good number of *A. aletiæ* reared then developed on these unhealthy caterpillars. In 1927 (11), the single adult obtained emerged on July 13. The first adult in 1928 appeared in the Oak Harbor cages on July 16, and this stage was present during the rest of the month. The peak of emergence was reached on August 2, when most of the borers had transformed to moths. The flies were still at hand in fair numbers on

*In the earlier paper referred to above occurs the name *Aphiochaeta* sp., which is identical with *A. aletiæ* named in the same. Specimens reared after the paper was submitted for publication enabled Mr. C. T. Greene of the U. S. Nat. Museum to determine the species, which was not possible with the single, imperfect specimen sent at an earlier date to Dr. Aldrich.

August 10, and probably issue till about the middle of this month.

Aphiochaeta (*Phora*) *aletiæ* was described by Comstock (12) as a true parasite of *Alabama* (*Aletia*) *argillacea* Hbn., obtaining it in abundance from the chrysalis stage. The evidence for this view on the habit of the larva was, however, not conclusive.

Parasites from *Phlyctaenia tertialis* Gn.

This leaf tier has two generations per year both at Oak Harbor and Urbana. The winter is spent as mature larvæ in the hollow or pithy stems of old elder or weed stalks standing or lying in proximity to the feeding places of this stage. In April and May to June they transform to pupæ and the adults probably first oviposit in June. The eggs are placed in small masses on the under sides of elder leaves, the latter being tied and rolled later by the larvæ. When about to pupæ, the larvæ become deep pink. The first generation caterpillars, like those of the second which hibernates, forsake the leaves and descend into the stalks of dry elder or weeds to pass the chrysalis period. Oviposition by the second generation occurs from mid-July to September, and mature larvæ in hibernation were found as early as latter July.

HYMENOPTERA.

Meteorus loxostege Viereck.

The type of this Braconid was reared (13) from *Loxostege sticticalis*, the beet webworm, on April 14, 1910 by H. O. Marsh at Rocky Ford, Colorado, and a few specimens of this parasite were bred (14) from the same host in Ontario, Canada by E. H. Strickland. Further host records are given by Muesebeck (15): *Pyrausta futilalis*, College Park, Maryland, reared by A. B. Gahan; *L. sticticalis*, Nebraska, and Maxwell, New Mexico;" one labeled as reared from a 'Nelumbians pyralid' ," but bearing no locality label; one from Woods Hole, Massachusetts; and Muesebeck reared two specimens from *Pyrausta nubilalis*, Watertown, Massachusetts. The present writer has it from *Phlyctaenia tertialis* Gn. Hence, to date the species is known definitely only from Pyralid larvæ of the subfamily Pyraustinæ. It was easily the most plentiful hymenopterous parasite of *P. tertialis*. Most of the 48 specimens taken were reared indoors

during January, February and March of 1928, from elder stems collected at Urbana on October 29, 1927 and February 11, 1928, but the species is also fairly common at Oak Harbor. The host larvæ of both generations became mature and entered quarters for pupation before their *Meteorus* parasite larva issued from them. None were ever found to have pupated before the parasite came out to spin its cocoon. In the instance of the overwintering host larvæ, emergence of the parasite larvæ was delayed until spring, so that *M. loxostegei* passes the winter at Urbana as a larva, presumably of advanced size, in its host. Whenever a post-mortem examination was made, the exit hole of the parasite was located on the seventh abdominal segment behind the third pair of prolegs and chiefly on the side or venter. In a lot of material collected on May 12, 1928, a few parasites had already issued and formed their cocoons when found, and a number of others kept indoors after the above date appeared from the caterpillars by May 22. The cocoons of *Meteorus* are formed in that of the host beside the shrunken body of the latter. The cocoons are about 6 mm. long, and have a maximum diameter of 2 mm. They are light-brown in color, the form is elongate-oval, and the walls moderately thin. The adult is a plain light-brown insect 4 to 5 mm. in length.

New *P. tertialis* larvæ were not available on elder in nature until about the middle of June, hence the adult *M. loxostegei* obtained from the above material before May 31 after a pupation period of nine days in the laboratory had developed earlier than its kind out-of-doors.

An adult female reared from its cocoon on July 9, 1928 at Oak Harbor was placed in a cage of *P. tertialis* larvæ which also were reared, but from the egg stage. This female, introduced here at intervals from July 10 to 14, had died on the latter date. The leaf tiers in the cage were then 7 to 20 mm. long, or from one-third grown to almost mature. Four cocoons of this parasite were found here between July 24 and 27. Adults issued on August 1, 3, and 6, two on the first date. The pupation period was therefore approximately eight to ten days and development from egg to adult required about three weeks indoors in the summer. Every specimen obtained from this cage and elsewhere proved to be a female, and inasmuch as a generation of adults was reared as the progeny of an unfertilized female, *M. loxostegei* is parthenogenetic as far as present observations show. Muesebeck (15) reports that this mode of

reproduction also occurs in *Meteorus autographæ* Mues. However, the male of this latter species is known. *M. loxostegei* presumably attacks its host when, or before, it is half-grown to enable the parasite larva about ten days to mature before its host can pupate. The host generations overlap freely, and three or more generations of the parasite may develop annually.

Apanteles sp.

Apanteles sp. was reared in small numbers, but its empty or hyperparasitized cocoons were usually found commonly both at Urbana and Oak Harbor. Dr. L. O. Howard (16) describes *A. delicatus* whose habits are similar to those of *A.* sp. The cocoons, which are almost 4 mm. long, and yellowish-white, occur singly and fastened to the surfaces of elder foliage. The parasite was never reared from this caterpillar, and inasmuch as the host does not remain by the parasite, or on the leaf at all, there is no direct evidence now at hand to prove the host-parasite relation believed to exist here. But no other insect was ever seen to inhabit elder foliage, and the leaves bearing the cocoons invariably bore the typical injury caused by *P. tertialis* larvæ. Whether the caterpillars from which *A.* sp. issued recovered from the attack, fell to the ground, or attached themselves to die elsewhere was not learned. Only the isolated parasite cocoons on the top or the lower side of the leaf, usually one per leaf, could be found. Adults were reared on and about August 2, 1928 at Oak Harbor, and in the week preceding and the week following this date, the cocoons reached the highest number in the season.

Specimens of this species were also obtained in January from Urbana cages containing, when these were first established, mature, hibernating larvæ of *P. tertialis*. Remnants of this species were found beside a small cocoon in an old hibernaculum of this host in an old elder stem. Two perfect adults of this species were removed from their cocoons in which they died after completing their exit holes. Many empty cocoons were also seen in such hibernacula at other times. This shows therefore that *A.* sp. is carried into the winter cells of the host as an internal parasite, whereas in the summer it leaves the caterpillar before the latter goes into its pupation position which is the same as the winter quarters.

Hoplocryptus spp.

Two undescribed species of this Ichneumonid genus were obtained in small numbers. The adults are 8 to 10 mm. long, not including the ovipositor. The slightly smaller species has white pro- and mesocoxæ, whereas the hind coxæ are light brown, which is the color of this segment on all legs of the larger species. In both species the head, apices of the abdomen, and some of the thorax are black. The color is otherwise mainly yellowish-brown or darker; the tarsi and scutellum, and some areas on the head and prothorax, are creamy white.

One specimen of the first species was seen at Urbana in a laboratory cage on February 15, 1928 in its transparent whitish cocoon in the winter case of *P. tertialis* in elder collected on October 29, 1927. The adult appeared on February 29, 1928. Five other specimens were reared during the winter from similar elder material containing many *P. tertialis*. The four in the writer's possession are males. It was not observed whether their larvæ issue from the caterpillar or from the chrysalis of the host.

Two dead individuals of the second species were found lying beside their cocoons within the hibernation cell of a *P. tertialis*. Another was taken out-of-doors on May 24, 1928 in an old stem in the cocoon of this moth. The parasite was then in its larval stage, had issued only a short while before from a fresh chrysalis of *P. tertialis* (which winters as a larva), and was spinning its cocoon when found. The adult came from this cocoon about June 5. Another chrysalis of this moth, opened in the field in early June, contained a hymenopterous larva that filled its host completely. It may be that this was another of this *Hoplocryptus* sp. It failed to develop. These specimens were obtained at Urbana. One of the same species was reared by Mr. E. G. Kelsheimer at Oak Harbor on June 19, 1928 from a cage of old elder stems devoted to rearing *Achatodes zeæ*, but it is probable that this parasite came from a *P. tertialis*. These two species of moths are associated in such places in their larval and pupal stages. A total of nine specimens of this parasite was taken, four of which are females.

Phytodietus pulcherrimus (Cress).

Two females of this Ichneumonid, originally described from Connecticut in 1868 (6), were reared. It is black, and has all

regions of the body beautifully marked with bright yellow, which, on the abdomen, takes the form of narrow, segmental rings. The length is 7 mm., not including the ovipositor. They issued from elliptical cocoons about 10 mm. long, amber in color, and bearing a denser transverse band of light-brown at the middle. Both were in the mature larval state when found at Grays Siding (near Urbana) on May 13. On May 25 they had pupated (indoors) and were white with light-brown eyes. They were taken in old elder stems. One adult issued on June 8, and the other was fully developed in its cocoon on the same date. The elders contained empty chrysalises of *A. zeæ*, several mature noctuid larvæ of another species occupying deserted burrows of *A. zeæ*, and *P. tertialis*. Circumstantial evidence points to parasitism on larvæ of *P. tertialis*.

Phytodietus distinctus Cress.

Phytodietus distinctus Cress; first described in 1870 (6, vol. 3), measures 8 mm. in length not including the ovipositor and yas a plain black body, excepting the abdomen which is ringed hellow. The legs are mostly reddish-brown with the tarsi and hind tibiæ mostly brown. The cocoon closely resembles that of *P. pulcherrimus* above. The single specimen taken emerged through a subterminal hole in its cocoon on July 1, 1928. This species is a primary parasite of *P. tertialis*. The cocoon containing the immature parasite was found in the hibernaculum of this moth in an old elder stem at Reno, Ohio, late in June. It is probable that the parasite hibernates as an advanced larva within the over-wintering mature caterpillar.

Triclistus propinquus (Cress.).

The sides of the prothorax are deeply, broadly and obliquely grooved to receive the much swollen front femora. These features of the mesothorax are similar to those of the prothorax, but less so. The body is entirely black and the legs yellowish-brown. The length is 7 mm. Two males were reared from cages of elder stems containing *P. tertialis*. Both specimens of this Ichneumonid were obtained at Urbana, one on April 2, 1928 (indoors) from elder collected on February 11, and the other on June 21, 1928. The latter represents the normal date of appearance. The host is probably *P. tertialis*,

in as much as the first one was obtained before *A. zeæ* began its spring development as a larva. It was described (7) by Cresson from material taken in Colorado.

Sesioplex validus (Cress.).

Sesioplex validus (Cress.) (*Tryphon seminiger* Cress.), is represented in this series of parasites by a single male. It issued at Urbana on February 28, 1928 in a cage of old elder stems occupied by *P. tertialis* larvæ, on which it is probably parasitic. It is about 7 mm. long, its antennæ and body black. The front legs are entirely yellowish to reddish-brown, the middle legs the same except the tarsi which are ringed alternately white and black. The hind legs have the coxæ black, the trochanter joints black and brown, the femora mostly brown, the tarsi black, and each of the tibiæ with two black and two white rings. It is known in Connecticut (17), and the type material was obtained in Illinois (7).

Gambrus (*Cryptus*) *incertus* (Cress.).

This ichneumonid species was described (7) from Delaware. The writer took two males and a female. Its host relation was definitely determined by the discovery of the parasite larva in its cocoon formed on the remains of the larva of *P. tertialis* in its winter case in an old elder stem at Urbana. This condition existed on February 11, 1928 when the elder concerned was collected, hence the parasite hibernates as a larva, and if an endoparasite, issued from the host before winter. Its cocoon measures 8 mm. long, is deep brown, and bears very fluffy silk externally. Emergence was affected through a subterminal hole. The other came from an elder stem cage kept indoors in December, 1927, the elder material collected on October 29, 1927, at Urbana.

The male adult is 8 mm. long and the female slightly longer and more robust. The antennæ, head, thorax, and abdominal segments five to nine, are black; the rest of the abdomen and the legs, mostly, are reddish-orange. The apices of the hind femora and tibiæ, and the tarsal segments are black, excepting the third and fourth, and apical half of the second which are white.

Bassus (*Microdus*) *simillimus* Cress.

This Braconid species is represented by one female specimen found alive in a cage of old elder stems in the laboratory on February 10, 1928 at Urbana, Illinois, and is perhaps also a parasite in the larvæ of *P. tertialis*. Britton (17) states it is "on record as a parasite of *Eucosma strenuana* (Tortricidæ) and *Lixus scrobicollis* (Curculionidæ)."

It is of interest as pertaining to the habit relations of this parasite and the above hosts that all these host species spend much of their larval life under cover of folded leaves or in stems of plants. Cresson described it (21) from New Jersey, Pennsylvania and Illinois. Its head, antennæ, ovipositor sheaths, thorax, (excepting propodeum), most of the legs, and the abdomen are black. The propodeum and abdomen are pale sanguineous, and the tips of the hind tibiæ and tarsi are more or less fuscous.

Aenoplex nigrosoma Cushman?

This doubtfully determined individual was reared from the hibernaculum of a larva of *P. tertialis* on February 29, 1928 at Urbana. Its cocoon, which occupies a part of the cocoon of the host, is 6 mm. long, barely 2 mm. in maximum thickness and light grey in color. The adult issued from a hole near the end of the cocoon. The host was still a larva when the parasite grub emerged.

Eulimneria sp.

On May 15 and 30, 1928, respectively, two dead fragmentary specimens of *Eulimneria* sp. were removed from cocoons of *P. tertialis* collected on those dates from elder stems at Urbana. Here also the parasite cocoons are formed within the cells of the host larvæ. They have a length of more than 6 mm., the color is grey with a brownish tinge, and the adult issued through a terminal hole.

Gelis sp.

Records for this genus (Ichneumonidæ) indicate that the species are at least in part secondary parasites in the cocoons of *Apanteles* and similar forms. This undescribed species

measures 3.5 mm. in length and is rather slender. The color of the body is exceedingly variable from almost entirely fuscous to nearly wholly dull yellow, whereas the legs are usually mostly yellowish-brown. Seven winged and seven wingless specimens were reared in cages of old elder stems infested with *P. tertialis* larvæ during the winter of 1927-28 at Urbana. The cocoons of *Apanteles* sp. discussed earlier in this paper, and other Ichneumonid primary parasites of *tertialis* occurred in the cages, and it is supposed that *Gelis* sp. is a secondary parasite in one or more of these. The adult was one of the first species to appear after the establishment of the cage.

Eupteromalus viridescens (Walsh).

This Pteromalid is described more fully above as a secondary parasite from certain primaries on *Achatodes zeæ* (p. 10). Although not reared under direct observation, this is the only species of secondary parasite obtained that could have made the small holes seen in the cocoons of *Apanteles* sp. described herein and parasitic on *P. tertialis*. It was obtained commonly from elder stems in cages maintained during the winter of 1927-28 at Urbana.

Elasmus atratus Howard.

Dr. L. O. Howard (16) reared the type material of this species from *Apanteles hyphantria*, *A. delicatus*, and *Limneria valida*, all primary parasites of *Hemerocampa leucostigma*. The male has flabellate antennæ, and in both sexes the hind coxæ are very large and strongly compressed. Both sexes measure about 1.5 mm. long, and the bodies are chiefly black. Nine specimens were reared in a vial from the cocoons of the *Apanteles* sp. already discussed on page 16, and believed to be parasitic on *P. tertialis* and found very commonly on elder foliage at Oak Harbor. *E. atratus* issues from its host through a subterminal hole, and eight individuals developed from two of the *Apanteles* cocoons. Of the six specimens still at hand, four are females. Four of the six came from their host on August 6, and two on August 30, 1928.

DIPTERA.

Zenillia caesar (Aldrich).

Doctor Aldrich (18) described *Zenillia* (*Exorista*) *caesar* from specimens reared by Prof. Lawson Caesar from *Cacaecia* (*Archips*) *argyrospila* Walk. at Simcoe, Ontario, Canada. The summary of the records by Aldrich and Webber (19) gives the following additional localities or hosts of this Tachinid: *C. argyrospila*, Canyon City, Colorado, and Wenatchee, Wash. (in Walton's unpublished index); *Loxostege sticticalis* Linn., Greely, Colorado; *Pyrausta nubilalis* Hueb., West Medford and vicinity, Mass., and *Crambus trisectus* Walk., Lafayette, Ind. It is also known from New Mexico.

This species and *Nemorilla floralis* Fall., described below, are somewhat larger than the housefly, or 5.5-7.0 mm. long and moderately robust. The second antennal joint of *Zenillia* is much shorter than the third, whereas in *Nemorilla* this segment is nearly as long as the last. The color of both species is black and gray, and the bodies bristly.

Zenillia caesar proved to be second only to the Braconid, *Meteorus loxostege* Vier., numerically as a parasite of *P. tertialis*. Twenty-seven individuals were reared as follows: seventeen Urbana specimens forced under laboratory conditions from December 22, 1927 to March 8, 1928 from old elder gathered in October and February; beside these, four issued indoors on May 12, 15, 17 and 19, from leaf tiers collected in nature on May, 1928; August 10, 1928, one from the host taken on July 26; at Oak Harbor, one was reared on August 6, another on August 8, and two more on August 20, 1928. Observations on over-wintered mature caterpillars of *P. tertialis* transported to indoor cages showed that the parasite larva issued always from the caterpillar of *P. tertialis*, and not from the chrysalis as noted in several instances of *Nemorilla floralis* below. *Z. caesar* spends the winter as at least a well developed maggot within its host. A considerable percentage of the host's hibernacula examined at Urbana in latter May already contained empty puparia beside the shrunken but still whitish remains of the host larvæ. This parasite probably has two or more generations each year.

Nemorilla floralis Fallen (*maculosa* Meigen).

On November 19, 1928, Dr. J. M. Aldrich informed the writer by letter that *Nemorilla floralis* Fallen "is now considered to be a prior name for *maculosa* Meigen." This species is referred to in the literature under various names (19, p. 5), and is recorded from both Europe and North America. Aldrich and Webber (19) redescribed it "from a long series of both sexes, from New England and Idaho to Cuba, the Virgin Islands, and Arizona. . . . . The species has a voluminous literature in Europe, and has been reared many times in the United States, always from larvæ of moths and butterflies. It is recorded also from Canada."

Twelve specimens of this Tachinid were reared by the writer from *P. tertialis* material in cages. Three of these are from Urbana, dated January 12, March 8, and May 17, 1928. The Oak Harbor specimens issued in 1928, as follows: August 8, two; August 9, three; August 20, four; and August 25, one. Two of the Oak Harbor series were obtained under direct observation from the chrysalis of the host, one of them pupating within the chrysalis of the host, and the parasite adult forcing its way out through the cephalic end of the chrysalis. In the rest of the instances, the host must at least have been a mature caterpillar, if indeed it had not already pupated at that time.

Gaurax dorsalis Lw.

This beautiful Chloropid (Oscinidæ) fly with its black and yellow body about 2 mm. long was bred in spring and summer from cages of elder stems occupied by the larvæ or chrysalises of *P. tertialis* at both Urbana and Oak Harbor. The larvæ were not seen in action, but judging by scattered records of the habits of its generic relatives, and by the general condition in which it was taken, *dorsalis* is probably a scavenger on the remains of other insects inhabiting the elder. Their food may have been the caterpillars killed by disease or the parasites, empty chrysalises of the moth, or even the discharged solids in the empty cocoons of the many parasites that developed on the elder leaf tier.

SYNOPTIC TABLE

Order	Family	Genus	Species	Relationship	Host or Food
Hymenoptera	Vipionidæ	*Microplitis*	*gortynæ*	Primary parasite	Larvæ of *A. zaæ* and *P. nitela*.
Hymenoptera	Braconidæ	*Microbracon*	*lutus*	Primary parasite	Larvæ of *A. zeæ*.
Hymenoptera	Braconidæ	*Meteorus*	*loxostegei*	Primary parasite	Larvæ of *P. tertialis*.
Hymenoptera	Braconidæ	*Apanteles*	sp.	Primary parasite	Probably larvæ of *P. tertialis*.
Hymenoptera	Braconidæ	*Bassus*	*simillimus*	Primary parasite	Probably larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Epiurus*	*pterophori*	Primary parasite	Larvæ of *A. zeæ*.
Hymenoptera	Ichneumonidæ	*Amblyteles*	spp.	Primary parasites	Pupa of *A. zeæ*.
Hymenoptera	Ichneumonidæ	*Hoplocryptus*	spp.	Primary parasites	Larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Phytodietus*	*pulcherrimus*	Primary parasite	Probably larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Phytodietus*	*distinctus*	Primary parasite	Larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Triclistus*	*propinquus*	Primary parasite	Probably larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Sesioplex*	*validus*	Primary parasite	Probably larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Gambrus*	*cryptus*	Primary parasite	Probably larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Eulimneria*	sp.	Primary parasite	Larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Aenoplex?*	*nigrosoma?*	Primary parasite	Larvæ of *P. tertialis*.
Hymenoptera	Ichneumonidæ	*Gelis*	sp.	Secondary parasite	Probably in cocoons of *Apanteles* sp. et al.
Hymenoptera	Eulophidæ	*Miotropis*	*clisiocampæ*	Primary parasite	Pupæ of *A. zeæ*.
Hymenoptera	Pteromalidæ	*Eupteromalus*	*viridescens*	Secondary parasite	Cocoons of *M. gortynæ and M. lutus*.
Hymenoptera	Elasmidæ	*Elasmus*	*atratus*	Secondary parasite	Probably *Apanteles* sp.
Hymenoptera	Pteromalidæ	*Habrocytus*	sp.	?	?
Hymenoptera	Eurytomidæ	*Eurytoma*	sp.	?	?
Diptera	Tachinidæ	*Zenillia*	*caesar*	Primary parasite	Larvæ of *P. tertialis*.
Diptera	Tachinidæ	*Nemorilla*	*floralis*	Primary parasite	Pupæ of *P. tertialis*.
Diptera	Phoridæ	*Aphiochaeta*	*aletiæ*	Scavenger	Diseased larvæ of *A. zeæ*.
Diptera	Chloropidæ	*Gaurax*	*dorsalis*	Probably scavenger	Various elder stem inhabiting insects.

Discussion.

Of the 26 species mentioned in the Synoptic Table (p. 240) 22 are Hymenoptera. 17 of these are Ichneumonoidea, 12 belonging to the family Ichneumonidæ, 4 are Braconidæ, and one is a member of Vipionidæ (Hym. Conn.). All, excepting *Gelis* sp., are primary parasites, three attacking the larvæ of *Achatodes zeæ*, one (*Amblyteles* spp.)—(regarded here as a single species)— the pupal stage of this host, and 12 have been found with practical certainty to parasitize the larval stage of *Phlyctaenia tertialis*. *Hoplocryptus* spp. (2 species) may issue from the chrysalis of this moth. Other species whose host relations are described in the table above as probable may later prove to inhabit the pupal stage also. The other five Hymenoptera belong to the superfamily Chalcidoidea, with various host relations as stated in the table. The host relations of *Habrocytus* sp. and *Eurytoma* sp. remain unknown.

Two of the four Diptera are probably scavengers, and the two Tachinidæ are parasitic, one issuing from the larva, the other from the chrysalis, of *P. tertialis*. Thus, 22 of the 26 species recorded herein are at least probable primary or secondary parasites on the two elder infesting moths, *Achatodes zeæ* and *Phlyctaenia tertialis*. Five belong to the *A. zeæ* complex, both the larval and pupal stages of this host being sheltered by elder stems, and 16 are associated with *P. tertialis* whose larval or most vulnerable stage lives exposed on plant foliage hidden only by the rolled leaves of the food plant.

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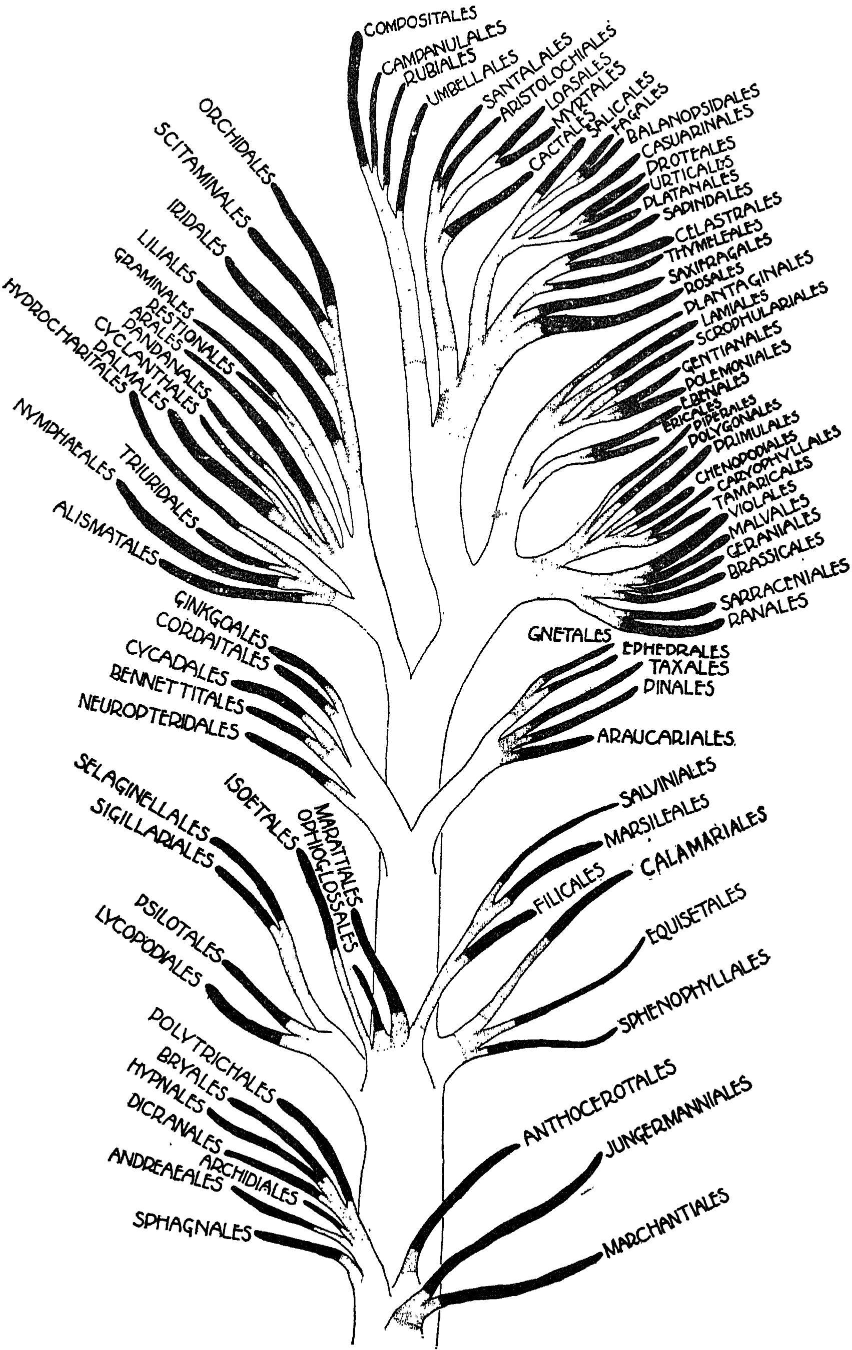
PRINCIPLES OF PLANT TAXONOMY, VII.*

JOHN H. SCHAFFNER.

Having considered the progressive stages of evolution and the correct sequence of the orthogenetic series, it becomes necessary to dispose of the fact of segregative characters thru which the present complex system of plant groups was brought about. It is evident that evolutionary progress is through individuals. If this were not the case, if the entire race evolved through a common property or impulse, then there would be no lower organisms left. For these would all have evolved to higher types long ago. The origin of the new individual or rather the new potentiality or group of potentialities does not alter the old which remain and perpetuate themselves just the same as before. This fundamental fact must be at the basis of any rational system of taxonomy. It must be recognized, however, that the same mutative change may take place many times in the same species or may also be repeated in any number of species or groups. Parallelism is very prominent in most plant groups. The progressions and parallelisms are easily discovered but the characters which are of a truly segregative value are often difficult to recognize. The true, phyletic system is, however, based on segregative movements, through which new and independent progressive lines are established. In the fourth paper of this series, the segregation into the great phyla was considered. The segregation will now be carried farther and the phyletic system of classification developed through to the orders. There are no criteria known for the delimitation of orders. They are simply the main phyletic branches of the classes and subclasses. In order to retain the "order" as a large branch or group an arbitrary numerical limit is set up and we thus say that ordinarily no class or subclass shall have more than seven, unless there is a very special reason for making more. This is a perfectly proper scientific procedure because it is the same kind of an exercise as the attempt to determine the number of large branches a tree may contain, or the number of large secondary branches in a still larger primary branch.


COMPOSITALES
CAMPANULALES
RUBIALES
UMBELLALES
SANTALALES
ARISTOLOCHIALES
LOASALES
MYRTALES
CACTALES
SALICALES
FAGALES
BALANOPSIDALES
CASUARINALES
PROTEALES
URTICALES
PLATANALES
SAPINDALES
CELASTRALES
THYMELEALES
SAXIFRAGALES
ROSALES
PLANTAGINALES
LAMIALES
SCROPHULARIALES
GENTIANALES
POLEMONIALES
EBENALES
ERICALES
PIPERALES
POLYGONALES
PRIMULALES
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CARYOPHYLLALES
TAMARICALES
VIOLALES
MALVALES
GERANIALES
BRASSICALES
SARRACENIALES
RANALES
ORCHIDALES
SCITAMINALES
IRIDALES
LILIALES
GRAMINALES
RESTIONALES
ARALES
PANDANALES
CYCLANTHALES
PALMALES
HYDROCHARITALES
NYMPHAEALES
TRIURIDALES
ALISMATALES
GINKGOALES
CORDAITALES
CYCADALES
BENNETTITALES
NEUROPTERIDALES
GNETALES
EPHEDRALES
TAXALES
PINALES
ARAUCARIALES
SELAGINELLALES
SIGILLARIALES
ISOETALES
MARATTIALES
OPHIOGLOSSALES
SALVINIALES
MARSILEALES
FILICALES
CALAMARIALES
EQUISETALES
SPHENOPHYLLALES
PSILOTALES
LYCOPODIALES
POLYTRICHALES
BRYALES
HYPNALES
DICRANALES
ARCHIDIALES
ANDREAEALES
SPHAGNALES
ANTHOCEROTALES
JUNGERMANNIALES
MARCHANTIALES

Since the plant kingdom falls very distinctly into Thallophyta and Metathallophyta, the two groups will be considered separately and the charts indicating the probable relationships and comparative levels will also be given in two separate plates. The writer is under obligation to Professor Floyd A. McClure, of Lingnan University, Canton, China, who made the final draft of the accompanying diagram of the phyletic relationships of the orders.

SYNOPSES OF THE CLASSES, SUBCLASSES, AND ORDERS OF THE METATHALLOPHYTA

Phylum, BRYOPHYTA.

I. Gametophyte with gametangia not imbedded in the thallus tissue; sporophyte not with intercalary growth between the sporangium and foot; sporangium not two-valved when a central columella is present.
  A. Rhizoids unicellular; mature gametophyte thalloid or a stem-like frond with scales; sporangium without a central columella, without or with elaters. HEPATICÆ.
    1. Gametophyte a thalloid dorsiventral frond composed of several distinct tissue layers, mostly with air passages; sporangium rarely opening by 4–8 valves. *Marchantiales.*
    2. Gametophyte a frond with stem and scales, or if flat and thalloid not composed of several distinct tissue layers; never with air passages; sporangium nearly always opening by 4 valves. *Jungermanniales.*
  B. Rhizoids multicellular or septate; mature gametophyte not thalloid; nearly always stem-like and covered with scales; sporangium nearly always with a central columella, if not, then without elaters.
    1. Gametophyte with a pseudopodium bearing the mature sporophyte; sporangium not with a complete columella, but with a dome-shaped cavity.
      a. Gametophyte gray-green, with two kinds of cells in the scales, narrow ones with chlorophyll and large ones without, but commonly with spiril fibrils; sporangium with an operculum. SPHAGNEÆ. *Sphagnales.*
      b. Gametophyte dark colored, not with two distinct kinds of cells in the scales; sporangium splitting into 4 or more valves. SCHIZOCARPÆ. *Andreaeales.*
    2. Gametophyte without a pseudopodium; sporangium nearly always with a complete columella, usually with an operculum and a well developed peristome of teeth. ODONTOCARPÆ.
        (1). Sporangium without a columella, the sporogenous and vegetative cells commingled. *Archidiales.*
        (2). Sporangium with a definite central columella, which may, however, in rare cases be absorbed.
      a. Peristome teeth thin, developed in the ampithecium and derived from the cell walls of a single layer of cells, always transversely barred; sometimes entirely wanting.
        (a). Peristome single, composed of two layers of plates made by a deposit on the inner and outer sides of the original cell wall, rarely wanting; usually acrocarpous. *Dicranales.*
        (b). Peristome double or sometimes wanting, the plates of the outer side of the teeth mostly in two rows by a zigzag median line, the inner side of the teeth of a single row of plates; endostome thin and membranous, sometimes lacking.

((a)). Archegonia situated on top of short, special, lateral branches; outer set of teeth usually alternating with the inner; frond usually of creeping habit; the so-called pleurocarpous mosses. *Hypnales.*

((b)). Archegonia situated at the tip of the main stem and of ordinary branches; frond usually of erect habit; usually acrocarpous mosses. *Bryales.*

b. Peristome teeth solid single or double, or rarely absent, developed from two tissue layers of the sporangium; consisting of entire cells, not transversely barred; or if developed from thickened parts of cell walls then the sporangium decidedly dorsiventral and zygomorphic; acrocarpous mosses. *Polytrichales.*

II. Venter of the archegonium sunken in the body of the gametophyte; rhizoids unicellular; sporophyte with prominent intercalary growth between the sporangium and foot; sporangium 2-valved, with a central columella. ANTHOCEROTÆ. *Anthocerotales.*

Phylum, PTENOPHYTA.

I. Sporophyte homosporous; gametophytes usually comparatively large and mostly hermaphroditic except in extreme forms. PHYLLOPTERIDÆ.

A. Sporangia eusporangiate in origin. Subclass, EUSPORANGIATÆ.

1. Sporangia on a sporangiophore distinct from the leaf blade and born on the morphologically upper side of the leaf; gametophyte subterranean, without chlorophyll. *Ophioglossales.*

2. Sporangia borne on the under side of the leaf blade, mostly forming synangia; leaves with 2 stipules; gametophyte with chlorophyll. *Marattiales.*

B. Sporangia leptosporangiate in origin. Subclass, LEPTOSPORANGIATÆ. *Filicales.*

II. Sporophyte heterosporous; gametophytes minute, unisexual; leaves not with ligules; sporangia in sori inclosed in a modified leaflet (sporocarp) or in the modified indusium; leptosporangiate. HYDROPTERIDÆ.

A. Sporangia in sporocarps; with creeping rhizomes; terminal bud with a 3-sided apical cell. *Marsieales.*

B. Sporangia in specialized indusia; small floating plants; terminal bud with a 2-sided apical cell. *Salviniales.*

III. Sporophyte heterosporous; gametophytes minute, unisexual; leaves with lingules and with sporangia borne singly, imbedded on the upper side near the base; eusporangiate. ISOETEÆ. *Isoetales.*

Phylum, CALAMOPHYTA.

1. Sporophyte homosporous; gametophytes hermaphroditic or unisexual.

A. Leaves not fused into a sheath; sporangia stalked, on the upper side of the sporophyll; stem with a central triarch vascular bundle; paleozoic fossils. SPHENOPHYLLEÆ. *Sphenophyllales.*

B. Leaves united into a sheath with teeth, sporophylls shield-shaped, with sack-like sporangia on the inner side; stem with a ring of vascular bundles and a central pith which is usually hollow. EQUISETEÆ. *Equisetales.*

II. Sporophyte heterosporous; gametophytes unisexual; paleozoic fossils. CALAMARIÆ. *Calamariales.*

Phylum, LEPIDOPHYTA.

I. Sporophyte homosporous; leaves without a ligule; gametophytes usually hermaphroditic. LYCOPODIEÆ.

A. Sporangia unilocular, Sporophylls undivided. *Lycopodiales.*

B. Sporangia bilocular or trilocular; sporophylls 2-parted. *Psilotales.*

II. Sporophyte heterosporous; leaves with a ligule; gametophytes unisexual. SELAGINELLEÆ.
- A. With increase in thickness of stem by means of a cambium; paleozoic fossil trees. Subclass, SIGILLARIEÆ. *Sigillariales.*
- B. Without increase in thickness of stem; present day herbs. Subclass, EUSELAGINELLEÆ. *Selaginellales.*

Phylum, CYCADOPHYTA.

I. Leaves usually compound; stem an unbranched shaft or with few branches.
- A. Megasporophylls only moderately or slightly differentiated from the foliage leaves; leaves fern-like, often very much compounded; no cones known; paleozoic fossils. PTERIDOSPERMÆ, *Neuropteridales*, and other imperfectly understood orders.
- B. Megasporophylls (carpels) highly specialized, usually very different from the foliage leaves; at least one kind of sporophylls in cones, the cones bisporangiate or monosporangiate. CYCADEÆ.
  1. Microsporophylls leaf-like; flowers probably all bisporangiate; fossil mesozoic plants with pinnate leaves. *Bennettitales.*
  2. Microsporophylls not leaf-like, arranged in compact monosporangiate cones; diecious, present day plants. *Cycadales.*

II. Leaves usually simple or lobed; venation dichotomous or parallel; stems with several or numerous branches, forming a crown.
- A. Without dwarf branches; leaves usually elongated, with parallel veins; fossil trees. CORDAITEÆ. *Cordaitales.*
- B. With thick wart-like dwarf branches and ordinary branches having well-developed internodes; leaves fan-shaped, dichotomously veined; sporophylls not in cones, the plant entirely flowerless; one surviving, living species. GINKGOÆ. *Ginkgoales.*

Phylum, STROBILOPHYTA.

I. No vessels (enlarged tracheids) in the secondary wood; wood frequently with resin ducts or cells; leaves mostly spiral, sometimes opposite or whorled; cotyledons 2–15. CONIFERÆ.
- A. Carpels usually numerous in ample or reduced strobili (cones); seeds covered by the carpel tips or by ovuliferous scales; cones rarely becoming fleshy when mature; seeds dry, the testa woody or leathery.
  1. Ovules single on the carpel; staminate cones large; sperms very large. *Araucariales.*
  2. Ovules 2 or more; staminate cones small; sperms not large. *Pinales.*
- B. Carpels of the cone few or one; seeds with fleshy testa or covered by a fleshy aril. *Taxales.*

II. Vessels present in the secondary wood; wood without resin ducts; embryo with 2 cotyledons; reduced strolili in specialized inflorescences; leaves opposite or in threes. GNETEÆ.
- A. Archegonia well developed; primary cambium persistent; leaves scale-like; stem green and fluted. *Ephedrales.*
- B. Archegonia reduced; concentric cortical series of vascular bundles produced; leaves ribbon-like or broad. *Gnetales.*

Phylum, ANTHOPHYTA.

I. Stems with closed, usually scattered vascular bundles; embryo usually with one terminal cotyledon and a lateral plumule; flowers mostly in threes, all except the lowest being of the pentacyclic trimerous type or a modification of this. MONOCOTYLÆ.

II. Stems with open vascular bundles, usually in a circle, with a cambium cylinder; embryo usually with 2 cotyledons and a terminal plumule; flowers mostly pentamerous or tetramerous, of many diverse types from low to high. DICOTYLÆ.

SYNOPSIS OF THE SUBCLASSES AND ORDERS OF MONOCOTYLÆ

I. Flowers with many to few free carpels, or the carpels united, in which case they are numerous, or if three, two, or apparently one, then the flowers in a spadix, usually with a spathe or the leaves segmented and fan-like or feather-like; a few with reduced flowers in glomerules and some aquatic plants extremely modified and without a perianth.

  A. Aquatic or mud plants, or rarely non-green phagophytes, with primitive or highly specialized flowers, but not in a spadix or dense glomerule; hypogynous or epigynous herbs. HELOBIÆ.

    1. Flowers hypogynous or somewhat perigynous or epigynous; carpels free or united, spiral or cyclic.

      a. Plants normal, with chlorophyll.

        (a). Hypocotyledonary expansion, if present, not lobed or only slightly notched; ovules usually anatropous or campylotropous leaves often narrow, not peltate and not with a narrow basal sinus but sometimes sagittate or deeply cordate; hypogynous. *Alismatales.*

        (b). Hypocotyledonary expansion parted into two lobes or deeply notched; ovules orthotropous; aerial or floating leaves peltate or with a deep basal sinus, or if somewhat sagittate then the carpels numerous and united; hypogynous to epigynous. *Nymphaeales.*

      b. Small yellowish or reddish phagophytes without chlorophyll; tropical plants growing in forests. *Triuridales.*

    2. Flowers epigynous; carpels united, cyclic. *Hydrocharitales.*

  B. Usually terrestrial plants, but sometimes aquatic; trees, shrubs, or herbs with segmented leaf-blades, or plants with the flowers in spadixes or dense glomerules, usually with spathes; or minute free-floating plants without leaves and with extremely reduced flowers; hypogynous, choripetalous, sympetalous or apetalous. SPADICIFLORÆ.

    1. Inflorescence not a typical spadix; leaves frequently plicate and more or less split at maturity.

      a. Leaves usually plicate and more or less split.

        (a). Carpels free or united, usually 3, forming a unilocular or plurilocular ovulary with one ovule for each carpel. *Palmales.*

        (b). Carpels united; ovulary uniocular, with numerous seeds on 2 or 4 parietal placentæ. *Cyclanthales.*

      b. Leaves linear or sword-shaped, not plicate and not splitting at maturity; flowers monecious, spicate or capitate. *Pandanales.*

    2. Inflorescence usually a fleshy spadix with or without a spathe; or minute plants without leaves, floating free, the flowers few or solitary, on the modified stem. *Arales.*

II. Flowers with united carpels, normally pentacyclic and trimerous or a modification or reduction of this type, often covered with glumes and then having a vestigial perianth or none whatever; if trees with pentacyclic trimerous flowers, then not in spadixes and the leaf blade not segmented.

  A. Flowers reduced, in spikelets covered with glumes, the ovulary nearly always unilocular; leaves narrow and usually elongated; usually with one or all the internodes elongated; always hypogynous. GLUMIFLORÆ.

    1. Ovulary 3-1-locular; ovules solitary in the cavities, orthotropous, pendulous. *Restionales.*

    2. Ovulary unilocular, one-ovuled; ovules anatropous, erect or ascending. *Graminales.*

  B. Flowers mostly showy and normally pentacyclic, or of a somewhat modified pentacyclic, trimerous type, rarely covered with glume-like structures; hypogynous or epigynous trees, shrubs, vines, and herbs of many types. LILLIFLORÆ.

1. Flowers hypogynous; seeds with endosperm. *Liliales*.
2. Flowers mostly partly or completely epigynous.
   a. Seeds with endosperm.
      (a). Flowers mostly regular, or only slightly zygomorphic. *Iridales*.
      (b). Flowers very irregular, usually zygomorphic. *Scitaminales*.
   b. Seeds without apparent endosperm, very numerous and usually minute; flowers mostly irregular and zygomorphic. *Orchidales*.

SYNOPSIS OF THE SUBCLASSES OF DICOTYLÆ

I. Flowers normally choripetalous or apetalous, some sympetalous but then mostly with central placenta; usually not epigynous and at the same time in umbels.
   A. Flowers hypogynous or perigynous, rarely epigynous.
      1. Floral organs usually inserted directly on the floral axis.
         a. Flowers with distinct carpels, or if the carpels are united usually with a plurilocular ovulary, if with a unilocular ovulary then usually with parietal placentæ; mostly with petals. THALAMIFLORÆ.
         b. Flowers usually with united carpels, the ovulary with a central ovule or placenta, often apetalous but sometimes choripetalous or sympetalous. CENTROSPERMÆ.
      2. Floral organs usually on a hypanthium which may be extremely reduced, in which case the flowers are commonly in aments or ament-like clusters; occasionally apparently epigynous.
         a. Petals commonly present; flowers not in ament-like clusters. CALYCIFLORÆ.
         b. Petals usually absent or much reduced; flowers commonly in aments or ament-like clusters. AMENTIFERÆ.
   B. Flowers usually epigynous, with or without a hypanthium, sometimes sympetalous. MYRTIFLORÆ.

II. Flowers typically sympetalous, rarely apetalous, but sometimes choripetalous and then commonly in umbels and epigynous.
   A. Flowers mostly hypogynous, if epigynous then the stamens opposite the lobes of the corolla or twice as many; occasionally the flowers are epigynous with alternate stamens.
      1. Flowers pentacyclic, or with as many carpels as petals, or if tetracyclic then the stamens mostly free from the corolla, if the stamens are united with the corolla then usually opposite its lobes. HETEROMERÆ.
      2. Flowers tetracyclic; carpels usually 3 or 2; stamens united with the corolla, as many as or fewer than its lobes and alternate with them; corolla mostly tubular. TUBIFLORÆ.
   B. Flowers epigynous, tetracyclic or less, with the stamens alternate with the corolla lobes, often in dense heads, if choripetalous then usually in umbels; calyx frequently minute or absent or replaced by a specialized pappus. INFERÆ.

The preceding synopsis of the subclasses of Dicotylæ probably does not give an entirely correct picture of the fundamental segregative movements. These are, in our present state of knowledge, difficult to discover in the enormous mass of more than 125,000 known species. The accompanying chart of the phyletic relationships is constructed on a somewhat different basis and indicates the evolutionary segregation to be about as follows:

I. Mostly hypogynous.
   A. Mostly choripetalous or apetalous.
      1. Mostly choripetalous and mostly not with central placentation. THALAMIFLORÆ.
      2. Typically apetalous but some choripetalous or sympetalous; mostly with central placentation. CENTROSPERMÆ.

B. Mostly sympetalous.
  1. Flowers pentacyclic or some reduction from this type; carpels commonly 5. HETEROMERÆ.
  2. Flowers tetracyclic or less; carpels mostly 2, occasionally 3. TUBIFLORÆ.

II. Mostly perigynous or epigynous, or with a reduced perigynous condition.
 A. Mostly perigynous and mostly choripetalous or apetalous.
  1. Petals commonly present; flowers usually not in ament-like clusters; hypanthium mostly prominent. CALYCIFLORÆ.
  2. Mostly apetalous; flowers at least the staminate commonly in aments or ament-like clusters; hypanthium mostly inconspicuous or reduced. AMENTIFERÆ.
 B. Epigynous, with or without a hypanthium; mostly choripetalous or sympetalous, occasionally apetalous.
  1. Mostly choripetalous and not in umbels; epigynous hypanthium frequent. MYRTIFLORÆ.
  2. Typically sympetalous, the choripetalous groups mostly in umbels; epigynous hypanthium rare; calyx often reduced or replaced by a specialized pappus; flower frequently in disks and heads. INFERÆ.

Subclass, THALAMIFLORÆ.

I. Carpels many to one, spiral or cyclic, usually free or only slightly united; stamens usually numerous. *Ranales*.

II. Carpels usually more or less united, cyclic.
 A. Herbs with insectivorous leaves; carpels 6–3. *Sarraceniales*.
 B. Herbs or woody plants with normal leaves, not insectivorous.
  1. Carpels 2 or more with parietal placentæ; perianth usually with an even number of segments, the flowers commonly partially or completely isobilateral. *Brassicales*.
  2. Carpels mostly 5 or 3; stamens mostly 10 or 5, or a reduction from 10; ovules mostly pendulous; flowers commonly of the hexacyclic type, one cycle being represented by glands. *Geraniales*.
  3. Carpels many to 3, ovules few; stamens indefinite, monadelphous, branched or clustered, or by reduction separate and few; sepals valvate. *Malvales*.
  4. Carpels 2 or more, commonly with parietal placentæ; stamens numerous to few; sepals and petals usually 5, sepals imbricated or convolute. *Violales*.

Subclass, CENTROSPERMÆ.

I. Perianth present, consisting of a calyx and corolla, or of a calyx only.
 A. Fruit not an achene or rarely so.
  1. Corolla usually choripetalous or none.
   a. Embryo straight; fruit a capsule. *Tamaricales*.
   b. Embryo curved, coiled, or annular.
    (a). Fruit a capsule, berry or anthocarp; calyx present; corolla present or absent. *Caryophyllales*.
    (b). Fruit a utricle; calyx present; corolla usually none. *Chenopodiales*.
  2. Corolla mostly sympetalous; fruit fleshy, or a dry capsule, utricle, or achene. *Primulales*.
 B. Fruit an achene; embryo straight or nearly so; stipules commonly ocreæ. *Polygonales*.

II. Perianth none or vestigial; ovules usually orthoptropous. *Piperales*.

Subclass, CALYCIFLORÆ.

I. Carpels free or united, spiral or cyclic.

A. Endosperm usually little or none; leaves mostly with stipules; carpels spiral or cyclic, often reduced to one, usually free or only slightly united, with a few evident exceptions. *Rosales.*
B. Endosperm present and usually copious; leaves usually without stipules; carpels cyclic, free or united, sometimes slightly epigynous. *Saxifragales.*

II. Carpels united, cyclic.
A. Hypanthium tubular or urn-shaped, often constricted above and enclosing the ripe fruit; endosperm commonly little or none. *Thymelales.*
B. Receptacle developing a glandular, annular or turgid disk which is somewhat united with the perianth or ovulary, endosperm present or none. *Celastrales.*
C. Disk tumid, united with the perianth, sometimes reduced; endosperm usually none. *Sapindales.*

Subclass, AMENTIFERÆ.

I. Flowers not in typical aments, often in pendent heads or ament-like spikes or clusters; usually monosporangiate.
A. Leaves alternate or rarely opposite.
1. Stamens alternate with the petals (when present), or numerous; perianth sometimes none. *Platanales.*
2. Stamens mostly 4, opposite the usually 4 sepals.
a. Calyx not petaloid. *Urticales.*
b. Calyx petaloid, stamens usually united with the sepals. *Proteales.*
B. Leaves whorled, reduced to scales; ovulary unilocular, with 2 ovules. *Casuarinales.*

II. Flowers, at least the staminate ones, in aments; monosporangiate.
A. Seeds not with a tuft of hairs, fruit a typical or modified nut, achene, or samara; plants monecious or diecious.
1. Fruit two- or several-seeded; ovules with one integument; diecious trees or shrubs. *Balanopsidales.*
2. Fruit usually one-seeded. *Fagales.*
B. Seeds with a tuft of hairs at one end; several in the capsule; flowers normally diecious, without perianth; leaves usually alternate. *Salicales.*

Subclass, MYRTIFLORÆ.

I. Petals usually numerous, rarely wanting; mostly fleshy, usually prickly and spiny plants with jointed stems and reduced leaves or the stem not jointed but the leaves fleshy. *Cactales.*

II. Petals usually not more than 5 or often none; trees, shrubs, or herbs not spiny like the preceding; calyx segments rarely more than 5.
A. Petals usually present, choripetalous; sometimes apetalous or sympetalous.
1. Flowers usually bisporangiate; placentæ usually axile or apical, rarely basal or parietal. *Myrtales.*
2. Flowers bisporangiate or monosporangiate; placentæ usually parietal; mostly herbs or herbaceous vines. *Loasales.*
B. Petals usually absent, if present either choripetalous or sympetalous.
1. Ovulary usually with several cavities, usually 6-locular; herbs or vines, sometimes parasitic. *Aristolochiales.*
2. Ovulary unilocular; mostly parasitic shrubs or herbs. *Santalales.*

Subclass, HETEROMERÆ.

I. Stamens mostly free from the corolla, alternate with its lobes or twice as many; seeds minute; flowers mostly bisporangiate, hypogynous or epigynous, sometimes choripetalous. *Ericales.*

II. Stamens united with the corolla and opposite its lobes or twice as many or more; seeds usually one or few in the cavities, usually large; flowers hypogynous or sometimes epigynous, sometimes choripetalous. *Ebenales.*

Subclass, TUBIFLORÆ.

I. Corolla not scarious, nerved.
  A. Fruit usually a capsule berry, drupe, or samara; carpels commonly severed- to many seeded.
    1. Corolla regular; stamens usually of the same number as the corolla lobes.
      a. Leaves alternate or opposite; ovularies not separating. *Polemoniales.*
      b. Leaves usually opposite, ovularies frequently separating below, with a common style; if not separating, then usually with 2 cavities or 2 placentæ. *Gentianales.*
    2. Corolla mostly irregular or oblique; fertile stamens commonly fewer than the corolla lobes except in the lower species. *Scrophulariales.*
  B. Fruit indehiscent but usually splitting and forming 4 nutlets around the style, rarely fleshy; carpels 1–2–seeded. *Lamiales.*

II. Corolla usually scarious, nerveless; calyx and corolla 4-lobed. *Plantaginales.*

Subclass, INFERÆ.

I. Anthers separate.
  A. Corolla choripetalous; flowers usually in umbels or cymes. *Umbellales.*
  B. Corolla sympetalous. *Rubiales.*

II. Anthers with few exceptions united; corolla sympetalous, sometimes absent.
  A. Flowers not in involucrate heads. *Campanulales.*
  B. Flowers in dense involucrate heads; gynecium of 2, or rarely 3, united carpels, unilocular; seed one. *Compositales.*

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DATA ON THE NUMBER OF SOMITES COMPARED WITH AGE IN THE WHITE RAT.

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The following report containing data on the relation between age and the number of somites in the rat is based on materials secured from the rat colony of the Department of Anatomy at the University of California during the summers of 1925 and 1926.

The material was collected at the suggestion of Dr. Herbert M. Evans with the object of studying the whole problem of the origin of the neural tube and the relation of the neural crest and placodes to the origin of the cerebral ganglia.

The publication of an extensive paper by Adelman ('25) on the neural folds and cranial ganglia of the rat, resulted in a change in the original program, the senior author being responsible for the later stages in development especially those involving the structure and possible contribution of the epibranchial placodes to the cerebral ganglia.

The effort to arrange a graded series of embryos, in order to follow the growth and differentiation of some particular structure which cannot be followed except in fixed material, always presents the uncertainty as to whether the series is as complete as possible and whether it is possible to predict the stage of growth and differentiation on some definite standard such as age or number of somites. When this can be done the grading of a series becomes a simple matter. When the variation between such criteria as age, length, weight and number of somites is pronounced then the problem of arranging a series to illustrate the growth of some particular body structure lacks the element of predictability largely, and the structure must be followed more or less independently and the uncer-

tainty of stating that any particular phase of growth or differentiation is absent is very great.

In order to arrange embryos in a series that would be as nearly continuous as possible it was decided to base the series on the age of embryos estimated from the time of deposition of the sperm plug. The mating was done by Dr. Evans after the proper stage in the oëstrus cycle had been determined from vaginal smears. Extreme care was exercised that the estimated time of deposition of the sperm plug should not vary in the records by more than five minutes although the age as recorded in the tables is given to the nearest hour. This was accomplished by examining each female after coitus at intervals of not more than five minutes. After the deposition of the sperm plug as determined by vaginal examination the female was removed from the breeding cage.

All males used in the mating were tested for fertility prior to use for this series, but females had not been previously mated. The extreme care exercised in the choice of both parents as well as the accuracy of the time of deposition of the sperm plug seems to the writers to reduce to a minimum whatever objections there might be to using the deposition of the sperm plug as a means of estimating the age of embryos. Whatever defect this method may have, due to variation in the time of ovulation and fertilization as compared with the time of deposition of the sperm plug, it is a convenient and easily controlled method and gives a definite standard from which to make comparisons.

The use of females that had not been mated previously may be open to some objection since in the rodents at least the variations in growth and differentiation and possibly in age may vary more with first matings than with later matings.

A characteristic of the Berkeley colony should be noted although it is not apparent why it should effect the variations between age and number of somites. The colony is descended from a cross between an albino rat from the Wistar colony and a wild gray rat, Swezey (26–28). The Berkeley colony shows two different chromosome counts, 42 and 62 with haploid numbers of 21 and 31 respectively, 42 being the number for both the albino and wild gray rat.

There is a further possibility that variations between the number of somites and age as estimated from the time of deposition of the sperm plug might be due to differences in time

of fertilization and this variation might be greater in first matings than in subsequent matings.

The observations of Long and Evans ('22) indicate that this difference as estimated by variations in ovulation is slight since ovulation occurs in first matings throughout a period of 12 hours, i.e., the last 12 hours of the II and III stages of the oestrus cycle, and following littering during a period of 8 hours, i.e., between 16 and 24 hours after littering, so that if one can estimate age by ovulation there should not be any marked variation in embryos due to first matings providing this variation is not greater between embryos of different mothers than between embryos of the two horns from the same uterus or between embryos from the same horn of the uterus. The four hours more or less assumed for the sperm to traverse the oviduct would normally transpire before ovulation was completed since the female accepts coitus during the II period of oestrus, i.e., presumably during the early part of the 30 hours involved in the II and III stages of the oestrus cycle and would not seem to furnish a basis for differences between age and number of somites.

While the collection of material was going on, examination made on single litters under the dissecting microscopes showed such variations in size and number of somites that it became apparent that arranging a graded series based on age as estimated from the deposition of the sperm plug would present serious difficulties and that these same difficulties might be encountered in the effort to describe almost any phase of the formation of neural crest, ganglia, or placodes and their relation to each other.

In the paper by Adelman ('25) cited above the conclusion was reached that there is no evidence for the contribution of cells from the epibranchial placodes to the ganglia of the VII, IX and X nerves in the white rat. Notwithstanding, the difficulties of following placodal cells as distinct from mesenchymal cells in birds and mammals, a difficulty which has been recognized for many years, there seemed to be a possibility for error in this case owing to difficulties of securing a series that was fairly continuous for any given structure when either age or number of somites was used as a criterion for determining where to look for a given step of the process if present.

Since marked variations occur not only between litters of the same age but between embryos of the same litter, both

between embryos of the right horn as compared with the left and even within the same horn these variations even with the precautions mentioned above make it evident that any effort to predict what could be expected to occur in any given case based on age or number of somites might be hazardous to say the least.

TABLE I.

ACCOUNTING FOR ALL EMBRYOS.

Age Days–Hrs.	Mother's Number	Left Uterus								Right Uterus								
		L1	L2	L3	L4	L5	L6	L7	L8	R1	R2	R3	R4	R5	R6	R7	R8	R9
10–12	W 2355	r	11	11	n	7	r	....	....	n	6	r	....	....	....	....	....	....
10–13	W 2221	r	8	13	i	r	9	12	....	8	11	....	....	....	....	....	....	....
10–16	W 2354	n	6	8	23	26	8	10	....	....	....	....	....	....	....	....	....	....
10–16	BH 2500	i	11	....	....	....	....	....	....	12	8	12	12	13	....	....	....	....
10–17	BH 2551	9	9	9	....	....	....	....	....	11	11	r	9	n	n	....	....	....
10–17	W 2573	19	4	12	....	....	....	....	....	10	n	13	n	i	14	15	....	....
10–17	GH 2226	r	r	14	13	....	....	....	....	r	r	n	r	7	26	r	....	....
10–17	W —12	15	15	14	15	16	....	....	....	13	15	15	15	15	14	14	....	....
10–17	B 2327	12	14	12	13	11	....	....	....	13	13	13	13	12	....	....	....	....
10–17	G 2326	16	8	13	13	10	16	....	....	r	11	11	14	....	....	....	....	....
10–18	B 2165	16	i	17	i	12	i	n	....	r	14	16	n	15	17	....	....	....
10–18	W 2258	r	8	6	i	n	n	n	r	....	....	....	....	....	....	....	....	....
10–18	W 2151	13	....	....	....	....	....	....	....	13	r	14	13	14	14	14	r	i
10–18	W 2520	17	9	17	17	....	....	....	....	n	n	18	n	13	18	n	....	....
10–19	W 2237	12	12	r	15	r	17	r	15	n	15	r	r	....	....	....	....	....
10–22	W 2586	15	9	9	8	i	n	....	....	13	12	i	n	....	....	....	....	....
10–22	W 2273	15	r	19	18	18	....	....	....	18	r	n	n	....	....	....	....	....
10–22	B 2342	9	r	6	....	....	....	....	....	n	14	14	13	n	....	....	....	....
10–23	B 2277	n	12	17	15	....	....	....	....	15	15	17	17	16	....	....	....	....
10–23	B 2577	16	....	....	....	....	....	....	....	17	8	15	18	14	13	....	....	....
10–23	W 2172	i	17	18	....	....	....	....	....	....	....	....	....	....	....	....	....	....
11–00	W 2282	r	r	r	....	....	....	....	....	r	15	17	14	r	14	15	15	....
11–00	BH 2198	14	17	....	....	....	....	....	....	i	10	....	....	....	....	....	....	....
11–02	GH 8424	21	22	21	21	r	....	....	....	21	20	22	22	21	....	....	....	....
11–02	GH 8975	r	21	22	21	....	....	....	....	17	r	22	19	r	....	....	....	....
11–04	W 8400	25	26	26	23	26	....	....	....	26	23	24	25	r	26	26	....	....
11–06	GH 8474	....	....	....	....	....	....	....	....	18	r	r	r	18	....	....	....	....
11–08	B 8415	23	r	28	....	....	....	....	....	25	24	25	24	28	23	....	....	....
11–09	W 8699	....	....	....	....	....	....	....	....	25	i	20	21	....	....	....	....	....
11–10	W 2162	22	23	r	25	23	....	....	....	23	26	n	r	24	n	....	....	....
11–10	B 2271	28	30	29	26	28	29	31	....	i	21	27	28	28	....	....	....	....
11–11	W 8426	28	27	25	28	....	....	....	....	i	26	i	28	29	28	28	....	....
11–11	W 2142	27	27	26	i	27	....	....	....	24	18	27	25	27	....	....	....	....
11–11	W 2357	23	25	26	26	n	i	26	....	23	27	14	....	....	....	....	....	....
11–12	W 2353	i	25	i	n	n	....	....	....	r	27	28	....	....	....	....	....	....
11–14	BH 2219	22	i	r	21	21	....	....	....	....	....	....	....	....	....	....	....	....
11–15	GH 2214	i	17	26	26	25	....	....	....	25	17	n	21	28	....	....	....	....
11–16	W 2572	n	27	27	n	n	28	26	....	24	28	27	....	....	....	....	....	....
11–17	G 2206	25	27	27	r	r	26	....	....	25	i	25	28	....	....	....	....	....
11–18	BH 2507	i	17	r	24	28	....	....	....	24	24	25	24	24	....	....	....	....
11–18	B 2194	24	27	25	26	n	28	....	....	25	26	26	26	27	....	....	....	....
11–18	BH 2197	26	i	27	24	28	....	....	....	26	26	26	i	....	....	....	....	....
11–20	W 2180	r	27	r	r	....	....	....	....	27	27	r	26	29	25	r	28	....
11–20	W 8426	28	27	i	28	....	....	....	....	i	26	25	28	29	28	28	....	....

KEY: r—resorption; i—injured; n—not in our lot. L1 and R1 embryos nearest ovary.

As a preliminary to the study of the variability in the formation of the placodes for instance as compared with age or number of somites the following tables are presented without any attempt to interpret them statistically except to call attention to their value as a basis for prediction since that is the practical value which such tables have when a series of embryos is arranged with a view to following any given structure in growth and differentiation.

Complete data are given in Table I showing the age to the nearest hour, the position of the embryo in the right or left

TABLE II.

SUMMARIZING DATA IN TABLE I.

Age Days-Hours	Total No. Embryos	Not in Our Lot	Injured	Resorbed	Number of Somites in Embryos Counted
10-12	9	2	....	3	6-7-11-11
10-13	9	....	1	2	8-8-9-11-12-13
10-16	14	1	1	....	6-8-8-8-10-11-12-12-12-13-23-26
10-17	62	5	1	8	4-7-8-9-9-9-9-10-10-11-11-11-11-11-12-12-12-12-13-13-13-13-13-13-13-13-13-13-14-14-14-14-14-14-14-15-15-15-15-15-15-15-15-16-16-16-19-26
10-18	42	9	5	5	6-8-9-12-13-13-13-13-14-14-14-14-14-15-16-16-17-17-17-17-17-18-18
10-19	12	1	....	5	12-12-15-15-15-17
10-22	27	6	2	3	6-8-9-9-9-12-13-13-14-14-15-15-18-18-18-19
10-23	19	1	1	....	8-12-13-14-15-15-15-15-16-16-17-17-17-17-17-18-18
11-00	15	....	1	5	10-14-14-14-15-15-15-17-17
11-02	19	....	....	4	17-19-20-21-21-21-21-21-21-21-22-22-22-22-22
11-04	12	....	....	1	23-23-24-25-25-26-26-26-26-26-26
11-06	5	....	....	3	18-18
11-08	9	....	....	1	23-23-24-24-25-25-28-28
11-09	4	....	1	....	20-21-25
11-10	23	2	1	2	21-22-23-23-23-24-25-26-26-27-28-28-28-28-29-29-30-31
11-11	31	1	4	....	14-18-23-23-24-25-25-25-26-26-26-26-26-27-27-27-27-27-27-27-28-28-28-28-28-29
11-12	8	2	2	1	25-27-28
11-14	5	....	1	1	21-21-22
11-15	10	1	1	....	17-17-21-25-25-26-26-28
11-16	10	3	....	....	24-26-27-27-27-28-28
11-17	10	....	1	2	25-25-25-26-27-27-28
11-18	30	1	3	1	19-24-24-24-24-24-24-24-25-25-25-26-26-26-26-26-26-26-27-27-27-28-28-28
11-20	23	....	2	5	25-25-26-26-27-27-27-27-28-28-28-28-28-28-29-29
Totals......	408	35	28	52	292 Embryos Counted.

horn of the uterus, the number of resorptions, the number of embryos injured so that counts of somites could not be made and the number of embryos not in our collection.

Table II is a summary of the data in Table I. A total of 408 embryos was found in the 44 litters. Of this number 35 embryos were sent to another university and no data are

TABLE III.

SHOWING MEANS AND VARIATION FOR EACH AGE.

Age Days-Hrs.	Number of Litters	Number Embryos Counted	Means	Maximum Variation All Embryos	Maximum Variation One Litter	Standard Deviation	Coefficient of Variation—%
10–12	1	4	8.7	6–11	6–11	2.8	32
10–13	1	6	10.2	8–13	8–13	1.9	19
10–16	2	12	12.4	6–26	6–26	5.8	47
10–17	6	48	12.9	4–26	7–26	3.3	26
10–18	4	23	14.1	6–18	9–18	3.1	22
10–19	1	6	14.3	12–17	12–17	1.2	8
10–22	3	16	13.1	6–19	6–14	3.9	30
10–23	3	17	15.2	8–18	8–18	2.4	16
11–00	2	9	14.6	10–17	10–17	1.9	13
11–02	2	15	20.9	17–22	17–22	1.3	6
11–04	1	10	25.3	23–26	23–26	1.2	5
11–06	1	2	18.0	18–18	18–18	.0	0
11–08	1	8	25.0	23–28	23–28	1.9	8
11–09	1	3	22.0	20–25	20–25	2.2	10
11–10	2	18	26.2	21–31	21–31	2.9	11
11–11	3	26	25.6	14–29	14–27	3.2	12
11–12	1	3	26.7	25–28	25–28	1.2	4
11–14	1	3	21.3	21–22	21–22	.5	2
11–15	1	8	23.1	17–28	17–28	4.0	17
11–16	1	7	26.7	24–28	24–28	1.3	5
11–17	1	7	26.1	25–28	25–28	1.1	4
11–18	3	25	25.4	19–28	19–28	1.9	7
11–20	2	16	27.2	25–29	25–29	1.2	4
23 Ages	44	292				Av. 2 2	Av. 13%

furnished in regard to them. They are marked "n" in Chart I. Unfortunately 28 embryos were injured in excision or handling, so badly that the somites could not be counted. They are designated "i" in Chart I. Fifty-two cases of definite resorption were found in the 408 cases observed and they are designated "r" in Chart I. Finally an accurate count of somites in 292 embryos or about 75% of all uterine enlargements was secured. A very wide difference in number of somites at many of the different ages should be noted. For example, at 10 days 17 hours the somite count ranges from 4 to 26, giving us an extreme variation. At 10 days 16 hours the range

is from 6 to 26 somites, and similar variations are found at a number of other ages.

In Table III the arithmetic mean number of somites for all embryos of each age is given. It will be noticed that these means would form quite an irregular curve. It is probable that the means from many thousands of cases would form a much more gradual curve and show a definite gradual growth. However, there are still wide variations within the group at any one particular age.

The standard deviations for each age have been computed and are shown in Chart III. These range from 0 at 11 days 6 hours, at which age we have only two embryos, each having a count of 18 somites, to 5.8 at 10 days 16 hours. The significance of this standard deviation of 5.8 can be appreciated much more readily if the coefficient of variation is computed. We find that this gives us the enormous coefficient of 47%. Although that represents our extreme variation for any one age, nevertheless, we have several other large coefficients and an average coefficient of 13%. This means that on the average each embryo contains a number of somites approximately 13% more or less than the mean for its age.

If we are liable to get coefficients of variation up to 47% for one particular age and can count on at least a deviation from the mean of 13% which would mean 2 or 3 somites and might mean as many as 12 or 13 somites, it seems reasonable to conclude that one is hardly justified in assigning a certain number of somites to an embryo of a certain known age. Further, in view of the fact that we have variations within a single litter of 7 to 26 somites (age 10 days 17 hours), it appears that one cannot be even reasonably sure of the number of somites in an embryo of any known age. The further inference is suggested that in the growth and differentiation of a particular structure when compared with a standard such as age, length, weight or number of somites in the rat, a wide range of variation might be encountered and might increase the difficulty of securing a complete series of growth changes.

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HYDROGEN ION CONCENTRATION AND TITRATABLE ACIDITY OF TOMATOES AND THEIR RESISTANCE TO FUSARIUM WILT.*

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INTRODUCTION.

The question of the nature of the resistance or susceptibility of plants to various diseases is one of the fundamental problems with which workers in the field of plant pathology have to deal. The literature on the subject is extensive and varied. Many theories have been advanced to account for the striking differences of response among varieties of certain species of plants to the attacks of parasitic organisms. One of the numerous theories suggested is that the acidity of the sap may be a determining factor in the resistance or susceptibility of plants to certain diseases.

The present paper is a report of work on the relation between hydrogen ion concentration and titratable acidity and the resistance of tomatoes to Fusarium wilt.

1. HYDROGEN ION CONCENTRATION AND RESISTANCE.

Review of Literature.

Hawkins and Harvey (4) found that the H-ion concentration of potato varieties was not related to their property of resisting the attack of *Pythium deBaryanum*. Hurd (5) made extensive investigations of the H-ion concentration of several varieties of wheat and concluded that there was no correlation between this factor and their resistance or susceptibility to certain diseases. Tims (11) investigated the pH of cabbage varieties resistant and susceptible to Fusarium wilt and found that, although there were some variations between the varieties, the differences were not large enough to be significant. Smith and Quirk (10) found that certain begonias which possessed high

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acidity were very resistant to crown gall infection. Furthermore, if the begonia juice was pressed out and neutralized, the crown gall organism grew very well in it. They also state that all plants known or suspected of being immune to crown gall have been found, as far as tested, to have juice more acid than pH 5.7, which is the limit of growth of *Bact. tumefaciens* in bouillon media and in acid juice.

Methods.

Two precautions were exercised in order that the H-ion concentration of all plants might be as equally influenced by environmental conditions as possible. Since there is a possibility that wilt infection might alter the normal acidity of the plants, they were grown on "wilt-free" soil, and were, in addition, clinically examined for incipient wilt infection before being used as a source of juice for the determinations.

Haas (3), Truog (12) and others have reported that the reaction of the soil in which certain plants are growing influences their hydrogen ion concentration. Care was taken, therefore, to test the soil of all the plots in which the plants were grown and it was found to be fairly uniform, about pH 7.20.

For the determinations of pH and total acidity the plants were brought into the laboratory and portions of the stems cut into short pieces. The pieces were washed and wiped dry, wrapped in cheese cloth, and placed in a 3-inch pipe cap. Another pipe cap, slightly smaller than the first, was set over them. The cylinder and piston thus formed by the two caps were placed under the screw of a letter press mounted on a vertical frame and pressure was applied. About 25 to 30 cc. of juice were squeezed from the younger parts of tomato stems at one pressing. The whole operation required about three minutes.

Actual and titratable acidity were determined electrometrically. The apparatus consisted of a quinhydrone electrode, a Leeds and Northrup type K potentiometer and type R galvanometer, a saturated calomel cell, and a two percent agar bridge saturated with KCl. The system was frequently checked with M/20 potassium acid phthalate solution (ph 3.97) as recommended by Clark (1) to determine its accuracy.

Ten cubic centimeters of the juice were transferred to a beaker and .2–.3g. of quinhydrone added and stirred. In two or three minutes equilibrium was reached and a reading made.

The adaptability of the quinhydrone electrode for determining the pH and titratable acidity of the tomato juice was ascertained by comparing it with the standard hydrogen electrode. Determinations of the pH values and of the titratable acidity of comparable samples of expressed tomato juice

TABLE I.

HYDROGEN ION CONCENTRATION IN pH UNITS OF DIFFERENT PARTS OF WILT RESISTANT (R) AND SUSCEPTIBLE (S) TOMATO PLANTS.

	Bonny Best S	Marglobe R	Norton R
Soil	7.20	7.20	7.20
Fiber roots	5.71	5.85	5.80
Large roots:			
Central cylinder	6.15	5.95	6.20
Cortex	5.44	5.58	5.45
Root stock			
Central cylinder	6.20	5.90	5.95
Cortex	5.61	5.60	5.55
Stem (at ground level)			
Pith	5.97	5.91	5.94
Rest of stem	5.73	5.77	5.80
Stem (one foot above ground)			
Pith	5.97	5.93	5.96
Rest of stem	5.97	5.88	5.90
Stem (two feet above ground)			
Pith	5.65	5.70	5.68
Rest of stem	5.65	5.70	5.69
Stem tip	5.58	5.61	5.64
Petioles	5.58	5.56	5.60
Leaf blades	6.06	6.01	5.98

made with both the hydrogen electrode and the quinhydrone electrode gave results agreeing very well. The differences between the pH values of the expressed juice obtained by the two methods were in the second decimal place as a rule. The titrations were carried to pH 7.00, as it was found that the quinhydrone electrode was not accurate in solutions less acid than this.

Results.

Table 1 summarizes the results of five determinations of the hydrogen ion concentration of various parts of mature tomato plants.

Fusarium lycopersici Sacc. usually enters the plant through the roots. It was thought that an investigation of the pH of the root systems of resistant and susceptible varieties might show some interesting differences but, as the results recorded in Table 1 show, this was not the case.

The data show that the different tissues of the tomato plants examined did not have the same H ion concentration.

TABLE II.

HYDROGEN ION CONCENTRATION IN pH UNITS OF THE EXPRESSED JUICE OF WILT RESISTANT AND SUSCEPTIBLE VARIETIES OF TOMATOES OF DIFFERENT AGES.

Stage of Growth of Plants	Bonny Best (S)	Earliana (S)	Norton (R)	Norduke (R)	Mar-globe (R)	La. Pink (R)
Seedlings (4″)........	6.10	6.08	6.11	6.12	6.23	6.09
Transplants (9″)......	6.07	6.05	6.02	6.05	6.09	6.04
Transplants (15″).....	5.92	5.87	5.83	5.79	5.81	5.80
Vining begun.........	5.83	5.79	5.75	5.81	5.70	5.73
First fruit setting.....	5.70	5.72	5.69	5.77	5.72	5.70
Mature fruit on vines.	5.38	5.40	5.46	5.40	5.42	5.43

However, similar tissues in the three varieties had about the same H ion concentration and therefore need not be considered further so far as wilt resistance is concerned.

Table 2 shows the pH values of the juice of wilt resistant and susceptible varieties of tomatoes at various stages of development. Each pH value given is an average of several determinations. All the plants except the youngest seedlings, which were started in flats in the greenhouse, were grown under field conditions.

The results recorded in Table 2 indicate that there were no significant differences in hydrogen ion concentration between the varieties used in the experiments at any given stage in the growth of the plants. It is evident, however, that the acidity of the plants increased as the season advanced and as the plants became older. Several factors may be involved in this increase of acidity. Hurd (5) has shown that wheat seedlings may vary

considerably in pH if their environment is changed. The data in Table 2 were taken at various times during the summer from May until September. Environmental conditions changed during that time and these changes may have been partly responsible for the increase. Hurd (6) has also found that there is an increase in the hydrogen ion concentration of wheat plants as they pass through the flowering and later stages. In the present case, since there was a regular progression from lesser to greater acidity as the plants increased in age, it is felt that the age of the plants was an important factor in the change. But, whatever may have been the cause of the increase in the acidity of the plants, all varieties changed to about the same pH values at the same time.

The data in Table 1 and 2 permit the conclusion that in tomatoes there is no correlation between the hydrogen ion concentration of the juice and the susceptibility of the plant to Fusarium wilt.

2. Titratable Acidity and Resistance.

Review of Literature.

Although it is evident that the hydrogen ion concentration of the juice is not the factor determining resistance or susceptibility to the wilt disease, it was thought possible that there might be significant differences in titratable acidity between the resistant and susceptible varieties.

Hurd (6, 7) found that the titratable acidity of wheat varieties was not correlated with their degree of resistance or susceptibility to *Puccinia graminis tritici* or to *Tilletia tritici*. Laurent (9) titrated the expressed juice of potato tubers resistant and susceptible to bacterial rot and found no relation between acidity and resistance. On the other hand Kirchner (8) found more titratable acid in two rust resistant and one smut resistant varieties of wheat than in an equal number of susceptible varieties. A more extensive review of the pertinent literature may be found elsewhere (7).

Methods.

The juice from growing stems was ordinarily taken for the determination of titratable acidity. Gustafson (2) found that the younger parts of some plants, although of less actual

acidity, may have a higher total titratable acidity than older portions of the same plants. A few determinations were made with this point in mind and it was found that in some cases the younger parts of the stems had more total titratable acid than the older parts, but in other cases there were no differences. However, in order to standardize the method, only the upper 8–10 inches of the stems were used. The juice was squeezed out by the method already described. Ten cc. constituted a sample which was titrated with .2 cc. increments of N/125 NaOH until the pH of the sample became greater than 7.00. Duplicate determinations were made on all samples.

TABLE III.

TITRATABLE ACIDITY OF TOMATOES TAKEN AT INTERVALS FROM SEEDLING TO FRUITING STAGE IN CUBIC CENTIMETERS OF N/125 NaOH REQUIRED TO NEUTRALIZE 10 CC. OF EXPRESSED JUICE.

Stage of Growth of Plant	SUSCEPTIBLE	RESISTANT			
	Bonny Best	Norton	La. Pink	Marglobe	Norduke
Seedling (5″)	1.15	1.20	1.17	1.23	1.21
Young plant (15″)	.50	.54	.58	.61	.60
First flowers open	.46	.49	.48	.48	.52
First fruit setting	.48	.53	.60	.55	.52
Mature fruit on vine	.40	.43	.38	.42	.46
Average, excluding 5″ seedlings	.46	.49	.51	.51	.52

Results.

Table 3 shows the average quantities of N/125 NaOH required to bring 10 cc. samples of the expressed juice to neutrality. The figures were obtained by plotting the titration values against the volumes of NaOH necessary to produce them. From the resulting curve the volume of NaOH required to bring the juice to neutrality (pH 7.0) was determined.

The figures given above are the average of a large number of titrations made at intervals throughout the season. The data show that seedlings have greater titratable acidity than older plants and that this factor is not constant during the growth period of the plants, either as the result of ageing or of changing environmental conditions. In so far as differences between the varieties are concerned there are none that can be considered significant from the standpoint of resistance or susceptibility to disease. It is true that Louisiana Pink,

Marglobe, and Norduke had a slightly greater titratable acidity than Bonny Best, but the total acidity of Norton, another resistant variety, was about the same as that of Bonny Best. Furthermore, if the toleration of high H-ion concentration in culture media by *F. lycopersici* and the tendency of this fungus to shift the pH of rather highly buffered acid media toward greater alkalinity can be taken as an idex of its ability to tolerate acidity in tomato, the varietal differences found are of little consequence as far as resistance is concerned.

SUMMARY.

1. The hydrogen ion concentration and titratable acidity of five varieties of tomatoes were determined at various stages in the growth of the plants.

2. Neither resistance nor susceptibility of these varieties of tomato to Fusarium wilt was correlated with actual or titratable acidity at any stage of growth of the plants.

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THE CRAYFISHES OF WEST VIRGINIA.*

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To the extent that a natural resource of a country has, in the eyes of its people, a distinct economic significance either from a utilitarian viewpoint or from that of a sportsman, in exactly that degree will it receive adequate attention necessary for its preservation. This idea is well exemplified in the case of the fisheries of the State. As soon as the depletion of a species sets in, the demand for information concerning its life history and habits increases.

In the study of crayfishes we cannot say, perhaps, that they possess at the present time any great economic value, positively or negatively. On the other hand, from the point of view of an ecologist, they present almost ideal material for studies of habitat preference, and for investigations to determine the influence of environmental factors on pigmentation. What determines whether a crayfish shall be red or blue or brown? Is it to be explained on a purely genetical basis? Perhaps the factor of age may be significant. Allee ('27) studied the methods of aggregation in the case of the brittle starfish (*Ophioderma brevispina*) and discovered that the aggregations were formed in the main by individual (primary) responses to environmental conditions rather than by social (secondary) impulses. The results of this study substantiate his former conclusions arrived at in his work with land isopods. (Allee '26) What are the types of aggregation, if any, in the case of Cambarus? This is an excellent field for research that is in need of elaboration. In this paper the author will give an account of the crayfish-fauna of the State of West Virginia, as complete as possible from the chorological, biological, and ecological standpoint.

This report has resulted from a belief on the part of the author that altogether too little is known concerning the conditions under which crayfishes subsist, more particularly, perhaps, those conditions that will lead to optimum growth and development.

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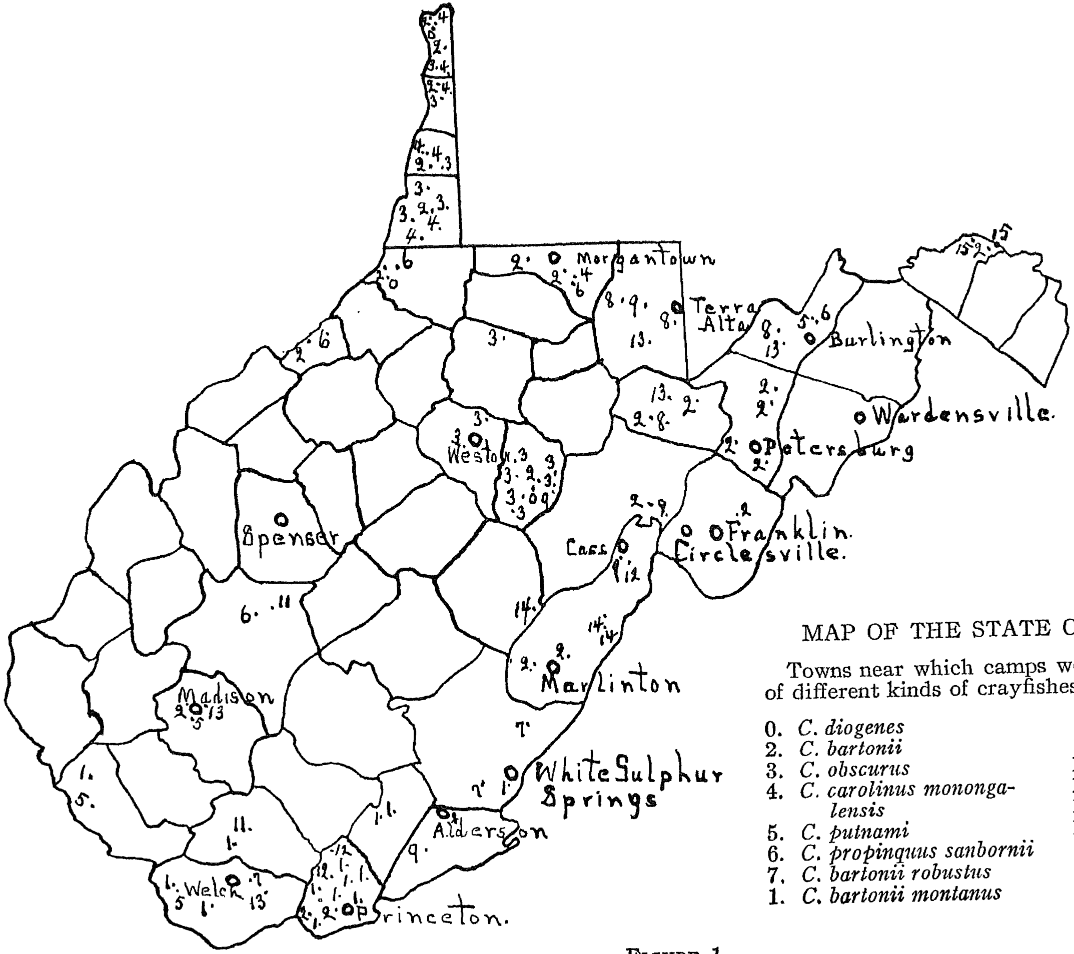
*Contribution from the Zoological Laboratory of West Virginia University.



MAP OF THE STATE OF WEST VIRGINIA

Towns near which camps were located. Districution of different kinds of crayfishes indicated by numbers.

0. *C. diogenes*
2. *C. bartonii*
3. *C. obscurus*
4. *C. carolinus monongalensis*
5. *C. putnami*
6. *C. propinquus sanbornii*
7. *C. bartonii robustus*
1. *C. bartonii montanus*
8. *C. carolinus carolinus*
9. *C. bartonii carinirostris*
11. *C. bartonii veteranus*
12. *C. bartonii longulus*
13. *C. carolinus dubius*
14. *C. carolinus dubius* (blue phase)
15. *C. limosus*

FIGURE 1

The material for this study was collected by the writer in connection with his work as a member of the West Virginia University Biological Expedition, consisting of students and instructors of West Virginia University carrying on field work in Bioecology.

The writer is indebted to Dr. A. M. Reese, under whose direction the study was conducted, for his invaluable assistance and guidance throughout the progress of the work. Thanks are due Dr. P. D. Strausbaugh for suggesting the problem and for many helpful suggestions and criticisms. Acknowledgment is made of the kindly assistance of Professor Weimer and the members of the West Virginia University Expedition who gave material assistance in collecting and to Dr. W. L. Schmitt for numerous identifications.

During the three months spent in the field (June, July, August, 1928) the party established successive headquarters in various regions of the State, each camp period lasting for about five days during which time field trips were made to the various points of ecological interest by means of autos. On the chart is listed the places in which collections of the various species were made, also all regions in which crayfishes have been hitherto collected in so far as these are included in the authentic records known to the author. (Figure 1).

At least eighty-five percent of the total area of the State of West Virginia consists of mountains and hills, the only broad valleys being those of the Ohio, Kanawha, Potomac and the Shenandoah rivers. Thus it is primarily a mountain state possessing wide diversity of physiographic conditions. To obtain a clear conception of the general surface features, West Virginia may be divided into three parts: (a) the Ohio Valley Section, (b) the Mountain Region, and (c) the Potomac Area. The first division includes about half of the State sloping westward from the Allegheny Mountains to the Ohio river. In all places the plateau is dissected by narrow valleys giving a great variety of habitats for animal and plant life. The altitude here ranges from 200 to 800 feet. The Allegheny region may be said to begin at the 1500 ft. elevation and includes thousands of mountain tops arranged irregularly, and deeply cleft. The highest ridge of the Alleghenies is Spruce Mountain located in Pendleton County, with an elevation of 4860 feet. The remainder of the State constitutes the Potomac system usually known as the Eastern Panhandle.

Despite the fact that there are no natural lakes in West Virginia, it is one of the best watered states on account of its never-failing springs, numerous streams, and creeks, winding their way around the mountain peaks and ridges. The entire drainage of the State with the exception of a small area in Monroe County is effected by two river systems—the Ohio and the Potomac. As will be emphasized later, these mountain streams and swiftly flowing creeks and rivers afford an excellent home for the *red crayfish*—furthermore, a study of some swampy areas lying beside the rivers revealed the presence of whole colonies of these interesting forms.

Historical Statement.

In so far as the writer has been able to determine, no extensive crayfish studies have ever been undertaken in West Virginia. Consequently, the credit for the data that we have at the present time goes to men, who, while engaged in Biological Survey Work in the neighboring states of Pennsylvania, Ohio, Maryland and Kentucky, made numerous expeditions into West Virginia. Here may be mentioned such men as Ortman, Faxon, Hay, Hagen, Turner and Williamson.

Ortman, late of the Carnegie Museum, has made extensive collections in Pennsylvania, northern and eastern Ohio and northern West Virginia. The records obtained prior to 1906 are included in the monograph "The Crayfishes of Pennsylvania" (Ortman '06). These furnish some valuable information concerning the habits, distribution, and ecological preferences of many common West Virginia species. He places special emphasis on the fact that the life history and habits of different species of the genus Cambarus are by no means similar, the differences being accounted for primarily by the different ecological conditions under which they live. Hay ('02) tells of having found the species *C. bartonii tenebrosus* abundant in several caves in Virginia and West Virginia. In this same locality he also collected an albinistic specimen.

In July 1899, Hay collected typical examples of *Cambarus bartonii carinirostris* Hay from the Tygarts Valley River at Beverly and near Elkins. He also secured a few specimens at Albright, Preston County, and at Queens, Upshur County, in the above named river basins. Again in 1900, he collected upward of 100 specimens of a crayfish closely resembling

C. putnami Faxon in southwestern West Virginia. Both Hagen and Faxon have made numerous excursions into West Virginia and some interesting information is contained in their report.

Sparganum-Ludwigia-Cambarus putnami Associes.

Some interesting field observations were made of the species *C. putnami* Faxon at a small swampy area which lies in the valley of Pond Fork between the stream and the base of the mountain situated about two hundred and fifty yards south of Uneeda Station, West Virginia. This region is a typical river valley so characteristic of those of West Virginia and the general level of the valley floor at this point is about 700 feet. The soil is of an alluvial character with a large admixture of humus.

A plot of ground 250 yards by 50 yards which composed the major portion of the swamp was selected for study (Figure 2). Five plots chosen as representative parts were marked off, the size of each being twenty-five square meters. The number of holes in each area was counted and checked and then an attempt was made to find the actual depth of one burrow in each of the five areas. Crayfish holes were observed in large numbers all about the margin of the swamp indicating a rather numerous population of these animals. The temperature of the water in the swamp was 28 degrees Centigrade. The dominant plants of this area were those of the Burr-reed Community (*Sparganum eurycarpum*), Marsh Purslane (*Ludwigia palustris*) and Swamp Loosestrife (*Decoden verticillatus*).

In the central part of the swamp there was a small clump of black willows (*Salix nigra*), the only woody plant in the entire area. The Plant Community was further characterized by the presence of several species of sedges (*Carex vulpinoidea, C. crinita, Dulichium arundinaceum*) and two rushes (*Eleocharis tenuis* and *Juncus effusus*), commonly found growing in such habitats.

The animal life of the water consisted mainly of tadpoles, salamanders, water striders, crickets, toads, frogs, snakes, insect larvæ, and various species of entomostraca. The following is a list of predominant forms observed in this associes:

Scientific Name	Common Name
Natrix sipedon	Water snake.
Hyla crucifer	Spring peeper.
Triturus viridescens	Yellow-backed Salamander.
Diadophis punctutus	Ring-necked Snake.
Heterodon contortrix	Hog-nosed snake.
Rana clamitans	Green frog.
Rana catesbeiana	Bull frog.
Bufo americanus	Common toad.

The accompanying diagram (Figure 2) will indicate the relative location of areas where following records were made.

AREA NO. I.

Hole No. 1.

Depth of water table below surface.................. 33 cm.
Depth at which crayfish was found.................. 86 cm.
Bottom not reached.

Hole No. 2.

Depth of water table below surface.................. 27 cm.
Depth at which crayfish was found.................. 72 cm.
Bottom not reached.
Number of crayfish holes—21.

AREA NO. II.

Hole No. 1.

Depth of water table below surface.................. 31 cm.
Depth at which crayfish was found.................. 48 cm.
Number of crayfish holes in area—37.

AREA NO. III.

Hole No. 1.

Depth of water table below surface.................. 37 cm.
Crayfish not found.
Depth of hole..................145.5 cm.
Number of crayfish holes in area—25.

AREA NO. IV.

Hole No. 1.

Depth of water table below surface.................. 42 cm.
Number of crayfish holes in area—11.

AREA NO. V.

Not tested for depth of water table.
Number of crayfish holes in area—21.

One hole in another part of the field was found to be over six feet in depth. The average number of holes in the five areas examined is 23, and on this basis the total number in the swamp is approximately 9615.

All the holes that were examined closely went straight down from four to eight inches, then they made an abrupt turn and continued downward to the water table. Crayfishes were seen lying near the edge of their burrow and it was found that upon the slightest stimulation they immediately crawled

over the edge and dropped into the holes. Thus it would seem that the perpendicular nature of the upper part of the hole is of advantage in that it affords an easy avenue of escape when attacked by enemies. It was not always possible to determine the full depth of the burrow because of the constant inflow of water. During the day crayfishes were usually found deep in their burrows.

Ortman ('06) distinguishes between three main types of ecological conditions among crayfishes. First, there are those species which generally live in the larger rivers; second, those preferring the ground water where it is not far from the surface and appears in the shape of springs and swamps; third, those that prefer intermediate conditions and select smaller streams

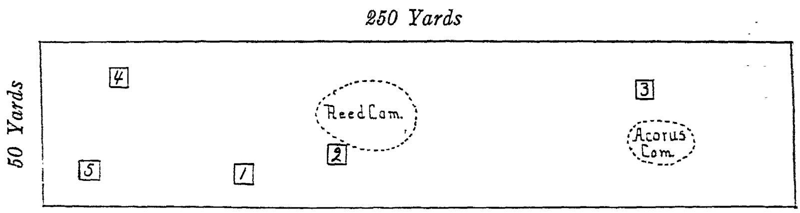


FIGURE 2
A drawing to show distribution of plots in the area in which studies of *Cambarus putnami* were made

for their homes. He aptly calls these the "river species," "mountain stream species," and the "burrowing species." Almost all the crayfishes of West Virginia will, in my estimation, fall in one of these categories, and so they will be used in the discussion that follows.

The data listed above would seem to point quite conclusively to the fact that *C. putnami* Faxon is a burrowing species. In the daytime, without exception, they were found in the ground water of their burrows. A few chimneys were observed at the entrance of some of the holes. Since the way of carrying the mud out of the holes seems to be identical in all burrowing species the following quotation from Ortman ('06) is of interest. "In digging, the chelæ of the first pereiopods are used. The fingers are slightly spread out so they are about parallel, thus acting as forks for digging. They are pushed vertically down into the mud on both sides at the same time and a lump of mud is thus loosened and lifted toward the ventral surface of the body. In lifting, the chelipeds are bent

toward the body (the region of the mouth), and finally the ball of mud is appressed to the anterior part of the body and held in position by the chelæ. Very likely, also, the third maxillipeds take hold of it but it was impossible to ascertain this. In this position, as Goodman expresses it, carrying an armful of dirt, (or rather two armsful), the crayfish walks slowly and deliberately to the mouth of the hole. I have repeatedly observed this coming out in nature. It advances to the top of the chimney and deposits the mud pellet upon the rim. Finally pushing it into proper position with the upper (outer) surface of the claws. This latter act apparently was seen by Mr. J. DeB. Abbot; but according to my experience the mud is not brought up upon the back of the claw but held as described above between the folded claws and the anterior part of the body."

In this particular region no chimney openings were found closed. In other regions of the state, such as at Welch, burrows of the species *C. bartonii robustus* Girard and *C. carolinus dubius* Faxon were found closed. The height of the chimneys averaged about nine inches.

How important a factor is the chimney of the crayfish habitat? Tarr ('84) states that he does not regard the chimney as a necessary part of the nest but simply the result of digging. In the estimation of Dr. A. E. Ortman, the construction of the hole is the chief aim for which the crayfish works. It not only affords protection for the crayfish and its young from such enemies as snakes, but protects the hole from the disturbing influences of rain and frost. Observations would indicate that females with eggs or young are usually found in closed holes. Various environmental factors such as slope of land and character of soil influence the shape of the chimneys. Young specimens usually build more regular chimneys than old ones, due probably to the fact that old specimens live in burrows that are practically completed, with the result that the mud that is removed is softer and makes rather irregular chimneys. Abbot ('84) is of the opinion that closed chimneys are caused by the falling in of the rim. On several occasions I have found burrows that were closed by a "stopper" extending down at least 18 mm. below the surface of the ground, and the firmness of the soil constituting the stopper was of such a nature that it could hardly be explained as an accidental falling in of the rim.

The above listed animals and plants present in the swamp are quite characteristic of the forms usually found in association with crayfish aggregations.

FOOD.

Observation of specimens in captivity as well as those in their natural environment leads one to believe that they are generally omniverous. They will eagerly devour almost any organic substance whether it be animal or vegetable. In captivity, I have known one instance in which *C. carolinus dubius* Faxon devoured a blue crayfish *C. carolinus dubius* Faxon (blue phase) (Newcombe '29) of almost equal size. On one occasion I observed a small form feeding on a dead fish. Some species are commonly known to devour their own cast off shell after moulting.

During the day crayfishes are usually found at rest, seeking shelter under a submerged log or rock crevice, while at night they are very active since it is at this time that they go in search of food. Quoting from Pearse ('10) "their activities are strictly utilitarian, being confined to such necessary movements as are concerned in mating, seeking and capturing food, and searching for environmental conditions."

DISTRIBUTION OF WEST VIRGINIA SPECIES.

The records of the localities and dates at which the different species of crayfishes from West Virginia have been reported, have been assembled and represented in the following tables:

TABLE I.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
C. putnami.....	McDowell	Barrenche creek, near Perryville	Summer of 1900	Hay
	Mingo	Horsefen Creek	"	"
	McDowell	War Creek	"	"
	Mineral	Patterson's Creek, near Burlington	Summer of 1928	Newcombe
	Boone	Near Uneeda	"	"
C. obscurus.....	Upshur	Queens	?	?
	"	Cheat River	?	?
	"	Ice's Ferry	?	?
	"	Sand Run	?	?
	"	Childer's Run	?	?
	"	Nubies' Run, near Buckhannon	?	?

TABLE I—Continued.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
C. obscurus....	Lewis	Weston	?	?
	"	Hacker's Creek, near Jane Lew	?	?
	Harrison	Ten Mile Creek at Lumberport	?	?
	Hancock	Harmon's Creek, (Holiday's Cove)	?	Ortman
	Randolph	Cassidy	?	"
	Brooke	Harmon's Creek, (Colliers)	?	"
	Monongalia	Decker's Creek above Morgantown	?	"
	Ohio	Wheeling Creek (Elm Grove)	?	"
	Marshall	Wheeling Creek (Union Township)	?	"
	"	Grove Creek (Cameron)	?	"
	"	Pennsylvania Fork of Fish Creek, Nuss.	?	"
	Wetzel	Fishing Creek, (New Martinsville)	?	"
C. propinquus sanbornii.....	Pleasants	Middle Island Creek	?	?
	Wetzel	New Martinsville Fishing Creek	?	?
	Mineral	Patterson's Creek near Burlington	August, 1928	Newcombe
	Monongalia	Near Morgantown	April, 1929	"
	Marshall	Fish Creek (Panhandle)	?	?
C. bartonii......	Morgan	Cherry Run	?	?
	Tucker	Blackwater Run, Davis	?	?
	Grant	Patterson Creek, South Branch of Potomac	?	Faxon
	Monongalia	Cheat River	?	Smith
	"	Morgantown	?	?
	Pleasants	St. Mary's	?	?
	Wetzel	New Martinsville	?	?
	Marshall	Cameron	?	?
	Ohio	Elm Grove	?	?
	Brooke	Colliers	?	?
	Hancock	Holiday's Cove	?	?
	"	Congo	?	?
	Pendleton	West Branch of Potomac River	?	?
	Mercer	Rich Creek	?	?
	"	Spanishburg	?	?
	Upshur	Nubies' Run, near Buckhannon	?	?
	Randolph	Glade Creek	?	Faxon
	Grant	North Hill Creek, near Petersburg	June, 1928	Newcombe
	Monroe	Wolf's Creek, near Alderson	"	"
	Boone	Jarrel's Run	"	"

TABLE I—Continued.

SPECIES	LOCALITY COUNTY	PLACE	DATE	OBSERVER
C. bartonii.....	Ritchie	Petroleum	?	Faxon
	Pocahontas	Cranberry (7 miles from Hillsboro	July, 1928	Newcombe
	"	Lion Lithia Springs, (near Dunmore)	August, 1928	"
C. bartonii robustus.....	MacDowell	Brook's Creek	July, 1928	Newcombe
	Greenbriar	Greenbriar River (near White Suplhur Spgs.)	"	"
	Greenbriar	West Fork of Greenbriar River	?	?
	Mercer	Crane Creek	?	?
C. bartonii montanus....	Greenbriar	Greenbriar River,	?	?
	"	Kanawha River	?	?
	Mingo	Horsepen Creek	?	Faxon
	Summers	Madam Creek, (near Hinton)	?	"
	Mercer	Bergens Springs, (near Hinton)	?	"
	"	Delasmeet Creek	?	"
	"	Kegley	?	"
	"	Bluestone River	?	"
	"	Abb's Valley	?	"
	"	East River	?	"
	"	Rich Creek	?	"
	"	Spanishburg	?	"
	Greenbriar	Barrenche	?	"
	"	War Creek	?	"
	Wyoming	Guyandotte River (Baileysville)	?	"
C. limosus......	Morgan	Potomac	?	Ortman
	"	Cherry Run	?	"
C. carolinus monongalensis	Ohio	Bethany	April, 1929	Weimer
	Hancock	Congo	?	Ortman
	Westmoreland	Bethany	?	"
	Hancock	Holidays Cove	?	"
	Brooke	Colliers	?	"
	Ohio	Elm Grove	?	"
	Marshall	Cameron	?	"
	"	Nuss	?	"
	Monongalia	Morgantown	?	"
C. carolinus carolinus....	Preston	Terra Alta	?	Faxon
	"	Reedsville	?	"
	Tucker	Parsons	?	"
	Mineral	Schell	?	"
	Southwestern	West Virginia	?	Hay

TABLE I—Continued.

Species	Locality County	Place	Date	Observer
C. bartonii carinirostris.	Randolph	Candee Creek Osceola	July, 1899	Hay
	Preston	Albright	"	"
	Upshur	Queens'	?	"
	Pocahontas	West Fork of Greenbriar River (near Dunmore)	?	"
	Monroe	Laurel Creek (near Greenville)	?	"
C. bartonii veteranus....	Wyoming	Indian Creek, (near Baileysville)	?	?
	Mercer	Crane Creek	?	?
	Kanawha	Elk River, Cogars' Mills	?	?
C. diogenes.....	Hancock	Congo	?	?
	Brooke	Colliers	?	?
	Wetzel	New Martinsville	?	?
	Monongalia	Cobun's Run, (Near Morgantown)	April, 1929	Newcombe
	"	Childer's Run, (Near Buchanon)	?	Faxon
C. bartonii longulus.....	Pocahontas	West Fork of Greenbriar River, (Near Durbin)	?	?
	Mercer	Bluestone River	?	?
	"	Abb's Run	?	?
C. carolinus dubius	Preston			
	Mineral			
	Tucker			
	Boone	Uneeda	June, 1929	Newcombe
	Mingo	Brooks Creek, (Near Welch)	July, 1929	"
C. carolinus dubius....... (blue phase)	Pocahontas	Cool Run, (near Cass)	August, 1929	Newcombe
	Pendleton	Spruce Mt. (Spruce Knob)	"	"
	Pocahontas	Bald Knob	"	"

In considering the distribution of individuals and species with reference to local factors such as temperature, purity and rapidity of stream, direct and detailed observations are very scarce, while conclusions as to distribution in the broader

sense, the range of species, groups and the genus itself are limited on account of insufficient investigation.

On the subject of the ecological phases of the distribution of crayfishes very little has appeared. Faxon ('85) records the occurrence of the same species in the headwaters of streams on the opposite sides of a water shed, as has been observed in fishes and gives as examples *C. extraneus* and *C. spinosus* in the upper waters of the Santee, Alabama and Tennessee rivers, and also states that the forms of the upper and lower part of a river may be different. To illustrate this point he gives *C. bartonii* and *C. latimanus*, *C. acuminatus* and *C. spinosus* in the upper part of the Santee River, while in the lower portion of the same basin live *C. blandingii acutus* and *C. troglodytes*. Only a relatively small number of observations have been recorded concerning the appearance of different species in different types of localities.

Crayfishes are found in a great variety of habitats from burrows in a prairie which is dry for a large part of the year, stagnant ponds, roadside ditches and salt marshes to the pure cold water of mountain streams and springs. Just as fish are known to be typical of each class of habitat, so, in all probability, are crayfishes, although, perhaps, to a less extent. It must be noted here that there are, in the limited literature on the habits and distribution of the different forms, numerous accounts of instances wherein the same species has been observed in entirely different environments. The author collected specimens of *C. carolinus dubius* Faxon at Brooks Creek, a cool swiftly flowing mountain stream, situated about two miles from Welch, W. Va., and also from a filthy stagnant pool near Morgantown. *C. putnami* Faxon, as will be shown later, was collected from two distinctly different types of habitat, one a swampy area at Uneeda, W. Va., the other a swiftly flowing stream, Patterson's Creek, two miles north of Burlington, W. Va. The species given are sufficient to illustrate the point in question.

It is possible to assign certain species quite definitely to some type of habitat. The burrowing species obviously have a great advantage over the other forms in the matter of distribution as they are able to occupy territory which is not available for others, except at certain seasons. *C. diogenes* Girard is the most widely distributed species of the genus, occurring in Boulder Co., Colorado at the foot of the Rocky Mountains

and in southeastern Wyoming, in Minnesota, Wisconsin, and Michigan; in New Jersey, Maryland, West Virginia, Virginia, North and South Carolina; and in Mississippi and southern Louisiana. *C. carolinus* long known from only the Appalachian region of Virginia is now known to occur in northeastern Indian Territory, Western Pennsylvania and West Virginia.

Among the species that appear to be confined to mountain streams may be mentioned *C. bartonii* Fabricius (common in West Virginia), *C. longulus* (also found in West Virginia), *C. extraneus*, *C. spinosus*, *C. acuminatus* and *C. forceps*. It is interesting to note the range in altitude as well as in longitude and latitude. *C. diogenes* Girard has been reported from Boulder County, Colorado and also southern Louisiana. I have observed a blue phase of *C. carolinus dubius* Faxon at an elevation of approximately 4500 feet at Spruce Knob, West Virginia, and also 2400 feet near Cass, West Virginia.

Discussion of Species.

It is not the intention of the writer to include in this paper a thorough taxonomic description of the various species of West Virginia crayfishes. Considerable attention will be paid, however, to *C. carolinus dubius* Faxon and *C. carolinus monongalensis* Ortman on account of their resemblance to a new color phase of *C. carolinus dubius* Faxon collected by the author at Cass, West Virginia.

Cambarus carolinus monongalensis Ortman.

Locality—Hancock County, Congo, Hollidays Cove;—Brooke County, Colliers;—Ohio County, Elm Grove;—Marshall County, Cameron, Nuss;—Monongalia County, Morgantown.

Cambarus carolinus dubius Faxon.

Locality—Mineral County, Preston County, and Tucker County.

New Locality—*Monongahela County, Westover, near Morgantown; MacDowell County, Brook's Creek, near Welch, West Virginia (U. S. N. M. No. 103761).

Cambarus carolinus carolinus Erichson.

Locality—Preston County, Reedsville;—Tucker County, Parsons;—Mineral County, Schell;—Southwestern West Virginia (Hay);—Preston County, Terra Alta (Faxon).

*Under this heading are listed regions in which the writer made collections.

DISCUSSION OF TAXONOMY.

These three species exhibit considerable similarity and there does not seem to be a generally accepted basis for differentiating them. For this reason, the writer has endeavored to follow the classification of Faxon and has considered the three groups together. *Cambarus carolinus monongalensis* Ortman, commonly known as the blue or Monongahela crayfish, was first collected at Pittsburgh, Pennsylvania in 1898, by E. B. Williamson. Compared with the type of *C. dubius* these specimens showed a narrower rostrum with less pronounced angles at the base of the acumen, the outer border of the hand was evenly rounded not ridged and destitute of the serrature seen in *C. dubius* where this feature results from the regular role of transversely elongated marginal punctations giving to the margins a milled appearance; further, the carpus of the Pittsburgh form was armed with several accessory spines and tubercles beside the prominent internal median spine which is all the armature of the carpus in *C. dubius*.

E. A. Ortman, '06, showed that the blue crayfish and *C. dubius* both live in western Pennsylvania, that they occupy different areas separated by the Chestnut Ridge, a range of hills on the west of the Allegheny Mountains, *C. monongalensis* Ortman being found on the hills lying on the west of the range, while *C. dubius* lives in the mountain region to the east of Chestnut Rige between it and the principle range of the Allegheny Mountains. In this same paper, Ortman brought out clearly the color difference between the two forms, the dominant color of *C. dubius* being red, that of *C. monogalensis*, blue. The range of the latter form appears to be rather narrow, being restricted as far as is shown by Ortman, to Westmoreland, Allegheny, Beaver, Washington, Fayette, and Green Counties, Pennsylvania, and Hancock, Brooke, Ohio, Marshall, Monogalia counties of West Virginia at altitude ranging from 800 to 1200 feet above sea level.

Ortman compared his specimens of *C. monogalensis* with the northern race of *C. carolinus*, i.e., *C. dubius*, and came to the conclusion that they represented a distinct species. From the above, however, it is seen that three of the characters which Ortman thought more peculiar to *C. monogalensis* are also present in the southern typical form of *C. carolinus*, viz., the narrower rostrum, the non-serrated margin of the hand,

and the presence of more than one spine on the inner side of the carpus. There are thus left but two features to separate *C. monongalensis* from *C. carolinus*, namely, the uniserial disposition of the spines on the lower face of the merus of the cheliped and the color. Taking a broader conception of the geographical variations of these interesting forms Faxon considers *C. carolinus* Erichson, *C. dubius* Faxon, and *C. monogalensis* Ortman as three geographical races or sub-species of one species. For distinguishing these three sub-species he gives the following key:

Lower face of merus with only one row of spines developed. Color, blue........*C. carolinus monongalensis* (Ortman)

Lower face of merus with two rows of spines developed. Color, red.....Margins of rostrum distinctly convergent; outer margin of band rounded, not serrated; more than one spine on inner margin of the hand.....*C. carolinus carolinus* (Erich.)

Lower face of merus with two rows of spines developed. Color, red.....Rostrum broader with nearly parallel margins; outer margin of hand subserrate; only one spine on inner margin of the hand, *C. carolinus dubius* Faxon

The form spread over the southwestern part of West Virginia, as has been pointed out, is more or less intermediate between *carolinus* and *dubius*, while the pure *C. carolinus dubius* has been reported from Preston, Tucker, and Mineral Counties, West Virginia.

Cambarus carolinus dubius Faxon (Blue Phase).

The writer collected two young blue specimens at Cass, West Virginia and assumed them to be *C. carolinus monongalensis* Ortman. On identification, Dr. W. L. Schmidt found that the distinguishing characters absolutely preclude this. He found them to possess the lateral compression of the carapace and the areola wider than would be expected for the young of *dubius*, yet too narrow for the young of *C. bartonii.* He writes as follows: "On described characters and comparing your small specimens with my much larger *monongalensis* they cannot be that species. This rather upsets the exclusiveness of color of the latter, for your evidence shows *dubius* to have a blue phase, at least in the case of some—your two young."? (Specimens).

At a later date, I sent him several blue specimens that were collected for me by Prof. Weimer at Bethany, Ohio County, West Virginia. These he found to be Ortman's sub-species *monongalensis* possessing the single row of spines on the wider side of the merus of the chelipeds. He writes as follows: "There is no question about these specimens, but I was concerned enough to go back and look at the *dubius* that we had retained from your former sending and that, to the best of my knowledge, is a good *dubius* because there are two rows of spines beneath."

New Locality—Pocahontas County, Cool Run, Cass; Bald Knob, near Cass;—Pendleton County, Spruce Knob (probably).

Habitat—Cool Run is a cold mountain stream, swiftly flowing and the crayfishes were not obtained from the stream but from their hiding places in the side of the bank, a few feet above the water. It was a damp, rocky area and they seemed to be concealed under the rocks. No characteristic burrows were observed in this area. From the stream were collected several specimens of *C. bartonii* Fabricius. A blue specimen was observed at Spruce Knob in Pendleton County, elevation about 4500 feet, and it is quite possible that it was the same blue phase of *C. carolinus dubius* Faxon since Ortman's *monongalensis* has not to my knowledge been reported as far south. It is worth noting that the range of the latter is from 800 to 1200 feet while that of the former is 2400 feet to 4500 feet approximately. Although all the areas where the blue phase of *C. carolinus dubius* were found were cool, damp regions, there is no evidence to indicate that they inhabit streams. This discovery of a new color phase in the genus *Cambarus* which encroaches on the exclusiveness of *C. carolinus monongalensis* Ortman leads us to ask, "What are the factors that control color in crayfishes?" Are we to look to genetics for an explanation or is it to be accounted for on a purely ecological basis?

C. carolinus dubius Faxon.

As far as is known the red crayfish *C. carolinus dubius* Faxon occupies a very small area of the State. The writer collected specimens from Brook's Creek, situated about two miles from Welch, West Virginia, and also at Westover, one mile north of Morgantown. The former was a shallow rapidly

flowing stream, water being noticeably cold and very clear; while the latter was a very stagnant shallow pool. In no case did the writer find the blue phase of this species in the water of the stream. They were obtained by digging in the bank of soil, probably three feet above the water. Not enough habitats of this group were studied to justify any opinion concerning the ecological preference of this type. Ortman, in comparing *C. carolinus* and *monongalensis* says that although they are very closely allied, nevertheless the distinguishing characters are constant; identical in their ecological habits they are separated topographically. As to the actual causes of the differences of the specific characters, or in other words what external influences are responsible for then, little is known at the present time. It is certain, however, that these two species illustrate the rule that closely allied species occupy neighboring areas and they illustrate the fact that specific differentiation is due to isolation which is topographical in this case.

Cambarus propinquus Girard.

LOCALITY—This species has a limited range in West Virginia, having been found only in the northern tip of the state.

C. obscurus Hagen.

LOCALITY—Upshur County, Cheat River, Ices Ferry, Sand River, Queens, Childers River, Trubies Run (near Buckhannon);—Lewis County, Weston, Backer's Creek (near Jane Lew);—Harrison County, Ten Mile Creek (at Lumberport);—Randolph County, Cassidy;—Monongalia County, Decker's Creek;—Marshall County, New Martinsville.

Cambarus propinquus sanbornii Faxon.

LOCALITY—Kanawha County, Horse Creek; Wetzel County, Fishing Creek, New Martinsville; Pleasants County, Middle Island Creek, St. Marys.

NEW LOCALITY—Mineral County, Patterson's Creek, two miles north of Burlington; Lewis County, Bushy Fork, seven miles northwest of Weston. (U.S.N.M. No. 103,761).

These three species (*C. obscurus*, *C. propinquus*, *C. propinquus sanbornii*) resemble each other very closely. They live under similar ecological conditions and their ranges form a unit so it is evident that they are closely allied genetically. Within the established range of *C. obscurus* from Fish Creek in the southern part of the Panhandle of West Virginia to the upper

Allegheny and the Genessee Rivers in McKean and Potter Counties and from Cheat River at the West Virginia state line to the upper Shenago River in Crawford County, Pennsylvania, this species is remarkably uniform in taxonomic characters (Ortman '06). As is pointed out above, *C. propinquus sanbornii* and *C. propinquus* G. have a very narrow distribution in West Virginia.

Cambarus bartonii Fabricius.

LOCALITY—Morgan County, Cherry Run; Tucker County, Black Water River, Davis, Shavirs Fork, Parsons; Monongalia County, Cheat River (H. H. Smith, Collector) Morgantown; Pleasants County, St. Marys; Wetzel County, New Martinsville; Marshall County, Cameron; Ohio County, Elm Grove; Brooke County, Colliers; Hancock County, Holiday's Cove, Congo; Pendleton County, West Branch of Potomac River, five miles west of Circlesville; Mercer County, Rich Creek, Spanishburg; Upshur County, Trubies Run, seven miles above Buckhannon.

NEW LOCALITY—Boone County, Jarrels Run (near Uneeda); Monroe County, Wolfs' Creek (near Alderson); Grant County, North Mill Creek (situated about five miles from Petersburg); Pocahontas County, Cranberry River (seven miles from Hillsboro), Lion Lethia Springs (one mile from Dunmore); Mineral County, Patterson's Creek near Greenland Gap.

HABITAT—*Cambarus bartonii* Fabricius is essentially a "mountain stream species." It prefers irregular cool well aerated mountain streams and also frequents springs but is seldom if ever found inrivers. During the day they are to be found along the banks hiding under rocks while at night they go in search of food. Sometimes they scoop out a hollow under a stone and establish their residence. Ortman ('06) reports instances of finding rather complex burrows of this species going down to a depth of a foot or more. These burrows extend along the banks of the streams usually not more than a few feet from the water's edge. *C. bartonii* Fabricius is not an habitual chimney builder and is more commonly found under the sheltered parts of rocks.

Cambarus bartonii robustus Girard.

LOCALITY—In the U. S. N. M., there are many specimens from the West Fork of the Greenbrier River, West Virginia and from Crane Creek, West Virginia, which are nearly typical examples of *Cambarus bartonii robustus* Girard according to Faxon ('14).

NEW LOCALITY—MacDowell County, Brook's Creek near Welch; Greenbriar County, the Greenbriar River near White Suphur Springs, West Virginia.

HABITAT—It is a common brook species found in habitats similar to *Cambarus bartonii* Fabricius.

Cambarus bartonii montanus Girard.

LOCALITY—Mingo County, Horsepen Creek; Summers County, Madam Creek, tributary of New River, opposite Hinton; Mercer County, Bergen's Springs, twelve miles from Hinton, Delasmeet Creek, Kegley, Mercer County, Bluestone River, just above its mouth. Mouth of Delasmeet Creek, Bluestone River, Abb's Valley, East River, Rich Creek, Spanishburg; MacDowell County, Barrenche Creek. Perryville, War Creek; Wyoming County, Guyanndotte River, Baileysville, West Virginia.

Cambarus bartonii carinirostris Hay.

LOCALITY—This is a slightly differentiated form of *C. bartonii* found chiefly in the mountain streams of Randolph County, West Virginia the Cheat and Tygarts Valley Rivers and their tributaries. Outside of Randolph County, Hay secured a few specimens at Albright, Preston County, and at Queen's, Upshur County, in the above named river basins. According to Faxon it is also probably to be found in the upper waters of the Kanawha River basin further to the south since there are a few specimens in the U. S. N. M., from the West Fork of the Greenbriar River near Durbin, Pocahontas County, and from Laurel Creek, in second Water Cave near Greenville, Monroe County, that are pretty characteristic examples of this race.

Cambarus bartonii longulus Girard.

LOCALITY—Pocahontas County, West Fork of the Greenbriar River near Durbin, Bluestone River and Abb's Valley.

Cambarus bartonii veteranus Faxon.

LOCALITY—Wyoming County, Indian Creek, Baileysville; Mercer County, Crane Creek; Kanawha County, Elk River, Cogar's Mills, West Virginia.

HABITAT—There have been few observations made on the forms of *C. bartonii longulus*, *C. bartonii veteranus*, and *C. bartonii carinirostris* and *C. bartonii longirostris*. It is quite safe to assume, however, that with regard to ecological preference they bear marked similarity to *C. bartonii* previously described.

Cambarus diogenes Girard.

LOCALITY—Hancock County, Congo; Brooke County, Collier; Wetzel County, New Martinsville.

NEW LOCALITY—The writer collected several specimens from Cobun's Run Creek near Morgantown questionably determined as this species by Dr. W. L. Schmidt of the Smithsonian Institution. He has informed me that there are in the Nat. Mus. at Washington, ten juveniles also questionably determined as this species over the name of Walter Faxon. These came from Childer's Run, three miles northeast

from Buckhannon, West Virginia. Ortman ('06) after a thorough search concluded that this form is positively absent in Preston, Tucker, and Mineral Counties, West Virginia.

HABITAT—*Cambarus diogenes* has the widest range of any species of Cambarus. It belongs to the burrowing group and its holes and chimneys are to be found along river banks as well as in meadows and marshes often occurring at some distance from open water. As a natural consequence of the habit of preferring swamps to springs, *C. diogenes* is generally found at a lower elevation than *C. carolinus* and *monongalensis* where it comes into contact with them. I have collected them from stagnant sewage offering a minimum of conditions favorable to respiration and other physiological life processes. According to Ortman ('06) in the case of *C. diogenes*, it is chiefly in mid-summer that the young begin to build their own holes. However, in other species this may take place at any time, from spring to fall and consequently the new and often very irregular chimneys of small specimens may be seen at any time during the warm season. Some valuable studies have been made on the burrows of this species by Faxon ('85), Girard ('52), Tarr ('84), Holder ('86) and Schiufeldt ('96), and others. Quoting from Hay ('96), "The subterranean tunnels may sometimes be found to extend for several feet and, as the animal frequently excavates them at some distance from the water, they must reach a depth great enough to supply moisture sufficient for the need of the animal. During the dry months of the summer, however, they seem to live in the end of their burrows in a sort of stupor. I have often seen them fall from the end of an excavation, apparently lifeless, capable of moving when put in water.

In the early spring, when they go forth to breed, is the only season when they are a noticeable number of our fresh water fauna. They move about chiefly at night though I have frequently taken numbers of them from ditches and small streams on bright sunny days."

Cambarus (*Faxonius*) *limosus* Rafinesque.

LOCALITY—The distribution of this species in West Virginia is very limited being reported by Ortman from the Potomac River and Cherry Run, Morgan County.

HABITAT—*C. limosus* is primarily a river species and belongs to the rivers, ponds and canals of the lowlands of the Atlantic Coastal Plain and the Piedmont region.

Cambarus putnami Faxon.

LOCALITY—MacDowell County, Barrenche Creek near Perryville; Mingo County, Horsepen Creek; MacDowell County, War Creek. Specimens closely resembling *C. putnami* were collected in 1900 by Hay.

NEW LOCALITY—Mineral County, Patterson's Creek, two miles north of Burlington; Boone County, near Uneeda, five miles from Madison, West Virginia.

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PRINCIPLES OF PLANT TAXONOMY, VIII*.

JOHN H. SCHAFFNER.

In the seventh paper of this series, a phylogenetic synopsis was presented of the orders of the META-THALLOPHYTA. A similar synopsis is now given of the orders of THALLOPHYTA. The two diagramatic "trees" of relationships may be put together and thus a crude picture of the phyletic relationships of the entire plant kingdom will be represented from the lowest stage to the highest with all the multitudinous ramifications out to the orders.

The Archemycetæ as described in the Ohio Jour. of Sci. *27:* 250, 1927, should be shifted in the list to immediately follow the Myxomycetæ and re-defined as being mostly sexual; since it now appears that most of them have some sort of a conjugation process.

There are many problems of a fundamental nature in the thallophytes which cannot be solved at present, because of a lack of knowledge of life histories. This is especially true of the lower green algæ, the lower brown algæ, the archemycetes, and the ascomycetes. So long as the genera and families are not properly segregated, it will be impossible to deal conclusively with the larger groups. This fact should not deter us, however, from attempting to make a correct phyletic taxonomy. Every careful attempt will bring the true taxonomic view nearer. The older morphological speculations, which did not distinguish progressive series from digressive movements or segregations, could not construct a true taxonomic system because they made no definite attempt to judge structures and individuals on a phyletic basis, but merely compared similarities and differences, and frequently deduced phylogenetic sequences which required a series of re-creations, if the one form was actually to be evolved from the other. Thus many of the taxonomic sequences which are at present widely accepted are a contradiction to any evolutionary theory of origins whatever unless one is willing to subscribe to the

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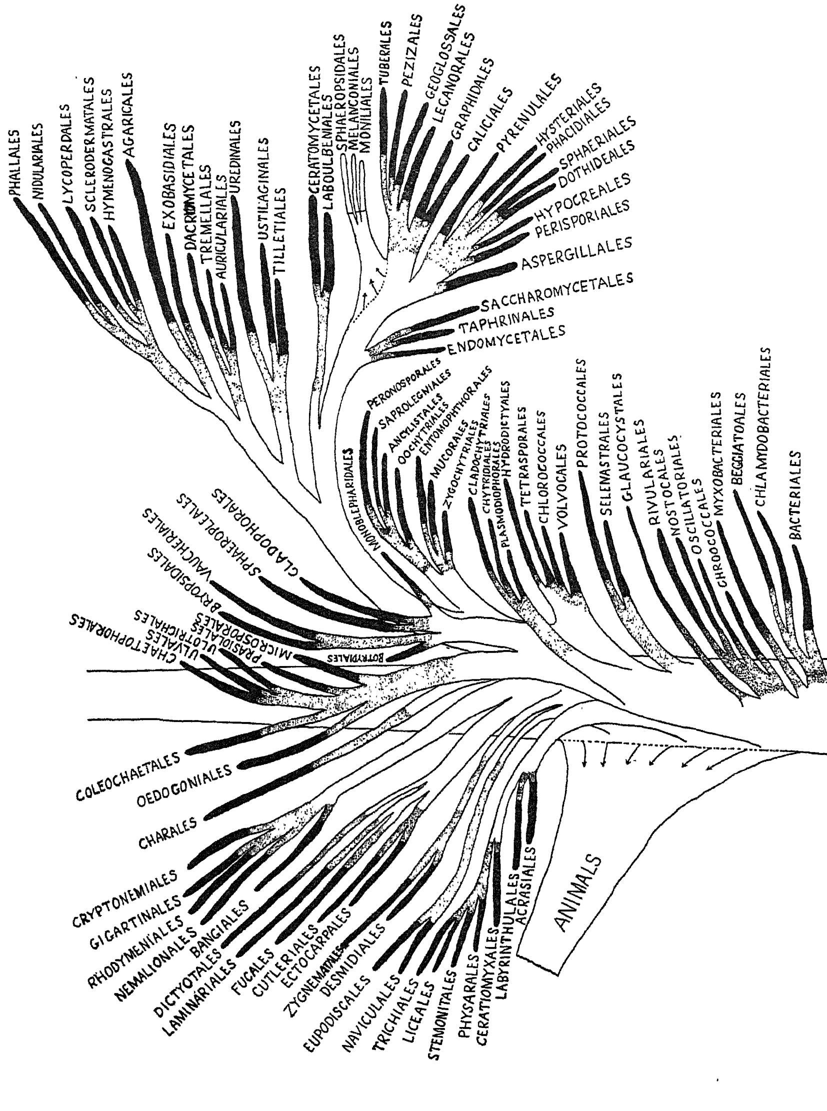

FIG. 1. Diagram of the phylectic relationships of the Orders of Thallophyta.

fantastic notion of frequent and violent re-creations in the phylogenetic series.

SYNOPSIS OF THE CLASSES AND ORDERS OF SCHIZOPHYTA.

I. Cells without chlorophyll, sometimes with bacterio-purpurin; holophytic, saprophytic, or parasitic fungi.
  A. Cells not imbedded in a pseudo-plasmodium; life cycle not with two distinct, vegetative and fruiting periods; not forming a myxomycete-like fructification, altho the cells may be in gelatinous masses. SCHIZOMYCETÆ. Bacteria.
    1. Cells without bacterio-purpurin and without sulfur granules; if in chains or filaments, then without a sheath. *Bacteriales*. Bacteria.
    2. Cells with bacterio-purpurin, with sulfur granules or with both; unicellular or filamentous; or filamentous bacteria with definite sheaths.
      a. Cells in filaments covered with a more or less definite sheath, without sulfur granules and without bacterio-purpurin. *Chlamydobacteriales*.
      b. Cells separate or if in filaments not covered with a sheath; with sulfur grains, or with bacterio-purpurin, or with both. *Beggiatoales*.
  B. Cells in a pseudo-plasmodium; life cycle with two distinct periods, a vegetative period and a fructification period when a myxonycete-like fruiting body is developed with or without a stalk. MYXOSCHIZOMYCETÆ.
    One order, *Myxobacteriales*. Slime Bacteria.

II. Cells containing chlorophyll and phycocyanin; algæ usually of a blue-green or brownish color.
  A. Without a definite nuclear membrane and with a low type of chromatophore. CYANOPHYCEÆ. Blue-green Algæ.
    1. Not filamentous; cells free or in masses or plates (superficial aggregates); or the cell individuals with definite base and apex, in fruiting sometimes forming a row of cells........*Chroococcales*.
    2. Cells arranged in definite filaments.
      a. Filaments without hair-like tips, but sometimes narrowed at the ends.
        (a) Without heterocysts; free filaments commonly massed into flat layers, sometimes several filaments enclosed in one common sheath........................*Oscillatoriales*.
        (b) With intercalary heterocysts..................*Nostocales*.
      b. Filaments with hair-like tips at one or both ends, without or with basal heterocysts........................*Rivulariales*.
  B. With nuclear membrane and highly differentiated chromatophores, unicellular or in colonies. GLAUCOCYSTEÆ. Higher Blue-green Algæ.
    One order, *Glaucocystales*.

SYNOPSIS OF THE CLASSES AND ORDERS OF MYXOPHYTA.

I. Without zoospores; the cells not fusing into a typical plasmodium, but simply aggregated; spore mass without a covering. ACRASIEÆ. Primitive Slime Molds.
  A. Cells ameboid, forming a typical aggregation plasmodium....*Acrasiales*.
  B. Cells not ameboid, but with rather rigid form, aggregating into a net-like plasmodium....................................*Labyrinthulales*.

II. With zoospores containing a single flagellum; plasmodium of completely fused cells. MYXOMYCETÆ. Slime Molds.
  A. Spores developed superficially upon erect branching sporophores, no sporangia being produced. Subclass CERATIOMYXEÆ.
    One order, *Ceratiomyxales*.

B. Spores developed within a sporangium-like body with a wall, the sporangia distinct or united into an æthalium. Subclass. MYXOGASTERÆ.
  1. Spores dark, brown, black, or violet; capillitium present.
    a. Fructification with lime, capillitium present.........*Physarales*.
    b. Fructification without lime; capillitium solid.......*Stemonitales*.
  2. Spores generally yellowish in color, never black; capillitium present or absent; lime absent.
    a. Capillitium absent; the frayed walls of the sporangium may sometimes resemble a capillitium....................*Liceales*.
    b. Capillitium present, tubular or solid.................*Trichiales*.

SYNOPSIS OF THE CLASSES AND ORDERS OF ZYGOPHYTA.

I. Cell walls impregnated with silica, composed of two valves. Subphylum and class, DIATOMEÆ. Diatoms.
  A. Valves with a raphe or pseudo-raphe or with a sagittal line, with a zygomorphic or insobilateral or sometimes irregular symmetry; never centric; valve-view mostly boat-shaped (naviculoid), rod-shaped, needle-shaped, or elliptic in outline; motile or non-motile; conjugation known in most groups. Mostly fresh water plants. *Naviculales*. Long Diatoms
  B. Valves without a raphe or pseudo-raphe, with a concentric or radiating symmetry around a central point, valve-view usually circular, polygonal, or broadly elliptical in outline, rarely boat-shaped or irregular; conjugation unknown; cells without spontaneous movement. Mostly marine plants.......*Eupodiscales*. Round Diatoms.

II. Cell walls without silica but with abundant development of gelatinous pectose, causing the plants to be slimy to the touch. Subphylum and class, CONJUGATÆ.
  A. Thallus a filament, or commonly separating into single cells, mostly flattened, the cell wall divided into two symmetrical halves; cells mostly constricted at the middle, often of fantastic and beautiful form; cell contents mostly divided into symmetrical halves; conjugation by the breaking open of the cell walls or by the formation of a primitive conjugation tube. Fresh water algæ. *Desmidiales*. Desmids.
  B. Thallus a simple filament, or occasionally with rhizoid-like outgrowths, with cylindrical cells, the cells not constricted in the middle, but sometimes the contents divided into symmetrical halves; these latter forms distinguished from the preceding order by the definite filament and prominent conjugation tube; some species forming aplanospores. In fresh and brackish water. *Zygnematales*. Pond-scums.

SYNOPSIS OF THE CLASSES AND ORDERS OF GONIDIOPHYTA.

I. Plants unicellular or colonial, not truly filamentous.
  A. Nonsexual, unicellular or colonial algæ without zoospores, commonly with autospores; cells normally with one nucleus. AUTOSPORÆ. Primitive Green Algæ.
    1. Reproduction by autospores, the protoplast dividing within the mother cell, and the daughter cells escaping singly or in colonies. In fresh, brackish, or sea water, or on moist rocks, etc.; some endozoic in water animals...........................*Selenastrales*.
    2. Reproduction by vegetative division and separation by splitting of the daughter cells. Aerial, on damp-stones, trees, etc., or in fresh or salt water.. ....*Protococcales*. (Pleurococcales).
  B. Sexual primitive, parasitic or occasionally saprophytic, aquatic or aerial fungi, or perhaps some nonsexual. ARCHEMYCETÆ. Primitive Fungi.
    1. Ameboid zoospores uniting into plasmodial masses; plants holocarpic; zoospores with one flagellum; parasitic in the roots of higher plants................*Plasmodiophorales*. Clubroot Fungi.

2. Zoospores not uniting to form a plasmodium, with one or sometimes two flagella.
   a. Plant body holocarpic, the whole forming a fructification; rhizoid-like processes, if present, without nuclei. *Chytridiales*.
   b. Plant body eucarpic, forming an imperfect mycelium-like filament, divided into principal and secondary axes. *Cladochytriales*.

C. Isogamous or heterogamous, sexual algæ or probable derivatives from them, with zoospores.
   1. Unicellular or colonial algæ, usually with one nucleus in each cell rarely cenocytic, the colonial forms not produced by the symmetrical aggregation of free zoospores; vegetative stage non-motile or active; isogamous or heterogamous. CHLOROCOCCEÆ.
      a. Cells ciliated and motile in the vegetative state; unicellular or in definite colonies.............................. *Volvocales*.
      b. Cells not active in the vegetative stage.
         (a) Vegetative cell divisions absent, cells separate or somewhat cenocytic............................ *Chlorococcales*.
         (b) Colonies increasing by vegetative cell division. *Tetrasporales*.
   2. Cenocytic algæ consisting of colonies of peculiar form, new colonies being produced by the definite arrangement of daughter cells developed in the parent cenocyte; isogamous, aquatic. HYDRODICTYEÆ. One order, *Hydrodictyales*.

II. Green algæ or aquatic fungi with a filamentous or massive body and 1, 2, 4, or many cilia on the zoospores and gametes.
   A. Cenocytic, septate or nonseptate, isogamous or heterogamous.
      1. Algæ usually pure green in color.
         a. Vegetative body usually septate, consisting of a series of cenocytes; chloroplasts forming a net, rarely in separate plates. SIPHONOCLADEÆ. Lower Tube Algæ.
            (a) Plants isogamous or slightly heterogamous; filaments branched.................................. *Cladophorales*.
            (b) Plants heterogamous, with stationary eggs and motile spermatozoids; filaments septate, unbranched, free-floating.................................... *Sphaeropleales*.
         b. Vegetative body usually nonseptate, with distinct lenticular, oval, or plate-like chloroplasts. SIPHONEÆ. Higher Tube Algæ.
            (a) Sexual reproduction unknown or isogamous, the gametes sometimes of unequal size.
               ((a)) Small globular terrestrial plants with branched rhizoids penetrating the ground; zoospores with cilia of unequal lengths................. *Botrydiales*.
               ((b)) Mostly large marine or sometimes endophytic algæ; zoospores if present not with unequal cilia. *Bryopsidales*.
            (b) Sexual reproduction by highly specialized stationary eggs and motile spermatozoids; thallus tubular, branched or unbranched, growing in fresh or brackish water or on moist soil.................................... *Vaucheriales*.
      2. Filamentous, saprophytic, aquatic fungi with stationary eggs and uniciliated spermatozoids. MONOBLEPHARIDEÆ. One order, *Monoblepharidales*.
   B. Algæ having normal vegetative cells with one nucleus, with a conjugation of free-swimming gametes, or with motile sperms and stationary eggs. CONFERVEÆ. Confervas.
      (A) Isogamous, or the free-swimming gametes sometimes of unequal size.
         1. Thallus unbranched.
            (1) Chloroplasts reticulate, without pyrenoids; fresh water plants....................................... *Microsporales*.
            (2) Chloroplasts central or parietal, with one or more pyrenoids.

a. Chloroplast single, central, stellate, with one pyrenoid; no zoospores known; aerial in habit. *Prasiolales.*

b. Chloroplasts parietal, with one to many pyrenoids.

(a) Unbranched filaments; chloroplasts with one to many pyrenoids. . . . . *Ulotrichales.*

(b) Thallus expanded, a 1-2-layered plane or tube; chloroplast single with one pyrenoid; mostly marine. . . . . *Ulvales.*

2. Thallus filamentous, branched, usually abundantly so, the branches often with attenuated or hair-like tips. . *Chaetophorales.*

B. Heterogamous, the egg stationary in the oogonium, sometimes with dwarf males as an intercalated phase.

1. Oogonium not developing a cortical layer after fertilization. *Oedogoniales.*

2. Oogonium with a trichogyne-like tip, and covered after fertilization by a cortical layer; thallus disk-like or cushion-like. *Coleochaetales.*

Synopsis of the Classes and Orders of Phaeophyta.

I. Zoospores when present and ciliated gametes with two flagella; if with an alternation of generations, then the gametophyte minute.

A. Gametangia plurilocular; zoospores produced in unilocular sporangia; apparently without an alternation of generations. PHAEOSPORÆ. Little Kelps.

1. Frond mostly filiform; zoospores and isogametes similar, rarely with gametes of unequal size. . . . . *Ectocarpales.*

2. Frond flat and leathery, with filamentous branches; heterogamous, with micro- and mega-gametes, both motile; zoospores on diploid individuals (?). . . . . *Cutleriales*

B. Gametangia unilocular or unicellular; zoospores none, or when present produced in unilocular sporangia and giving rise to minute male and female gametophytes.

1. With a simple diploid sexual cycle and without zoospores; gametangia unilocular; eggs large and non-motile, but discharged from the oogonium; sperms minute and free-swimming. CYCLOSPORÆ. Rockweeds.

One order, *Fucales.*

2. With an alternation of generations; nonsexual zoospores produced in unilocular sporangia and giving rise to small male and female gametophytes; gametangia unicellular; sporophyte often very large. LAMINARIEÆ. Giant Kelps.

One order, *Laminariales.*

II. Nonsexual spores non-motile; sperms with one flagellum; reproductive organs external; with a regular alternation of prominent sexual and nonsexual generations. DICTYOTEÆ. One order, *Dictyotales.*

Synopsis of the Classes and Orders of Rhodophyta.

I. Nonsexual reproduction by single thallus cells, trichogyne imperfectly developed; no pits between the thallus cells. MONOSPORÆ.

One order, *Bangiales.*

II. Nonsexual reproduction by tetraspores usually developed in groups of four; trichogyne well developed; cells protoplasmically connected through large pits in the walls. FLORIDEÆ.

A. Sporophores ("Gonimoblasts" or branches bearing the carpspores) of the sporocarp produced directly from the fertilized oogonium; mostly plants with filiform fronds. Fresh water or marine. *Nemalionales.*

B. Sporophores produced by auxiliary cells after these conjugate with the fertilized oogonia or their branching processes (ooblastema).

1. Sporophores produced by nearby auxiliary cells. Marine plants.
   a. Sporophores produced by nearby auxiliary cells and growing outward in the plant body; filiform, foliaceous, or massive plants..*Rhodymeniales.*
   b. Sporophores produced by the nearby auxiliary cells and branching copiously in the surrounding tissues of the plant body; fronds parenchymatous, erect or spreading, branching, cylindrical, flattened, or leaflike..................*Gigartinales.*
2. Sporophores produced by remote auxiliary cells after these have conjugated with the branched "ooblastema" filaments arising from the fertilized oogonium, fronds filiform, branched, often flattened. Mostly marine, but a few fresh water species. *Cryptonemiales.*

PHYLUM, CHAROPHYTA.

One class and one order, CHAREÆ. *Charales.* Stoneworts.

THE TWO SUBPHYLA OF MYCOPHYTA.

I. Plants with a cenocytic mycelium, without or with transverse septa. PHYCOMYCETÆ. Algal Fungi.
II. Plants with a septate mycelium, the vegetative cells containing one or two nuclei; normally with a conjugate phase in the life cycle. MYCOMYCETÆ. Higher Fungi.

SYNOPSIS OF THE CLASSES AND ORDERS OF PHYCOMYCETÆ.

I. Sexual spores, "zygospores," produced by the union of the contents of two similar or nearly similar conjugating branches of the mycelium, the one branch not penetrating the other; nonsexual spores rarely zoospores. Saprophytes or animal parasites, a few parasitic on other plants. ZYGOMYCETÆ.
   A. Nonsexual spores motile, with one flagellum. in terminal sporangia. Saprophytic, aquatic plants growing on dead insects.....*Zygochytriales.*
   B. Nonsexual spores nonmotile, in sporangia or abstricted conidia; saprophytic or occasionally parasitic on other molds or on higher plants..................................*Mucorales.* Common Molds.
   C. Nonsexual spores nonmotile, single at the ends of conidiophores; mostly parasitic on insects, as flies, grasshoppers, plant lice, etc., rarely on plants...............*Entomophthorales.* Insect-cholera Fungi.

II. Sexual spores, "oospores," formed by the union of the contents of two conjugating branches of unequal size, the smaller usually penetrating the wall of the larger by means of a fertilization tube; or discharging its contents into it, sometimes parthenogenetic; nonsexual spores, either zoospores with one or two cilia, or conidia. Plant or animal parasites or saprophytic, sometimes aquatic. OOMYCETÆ.
   A. Nonsexual reproduction not by conidia; mostly aquatic fungi; a few on higher aerial plants.
      1. Mycelium present but poorly developed, either free or endophytic parasites; oospores formed by the conjugation of a larger and a smaller branch of the mycelium, the contents of the smaller branch passing over into the larger..................*Oochytriales.*
      2. Mycelium usually poorly developed, with septa; endophytic parasites, mostly in fresh water algæ, some in the roots of higher plants; sporangia producing zoospores................*Ancylistales.*
      3. Mycelium well developed; mostly aquatic molds; saprophytic or parasitic; nonsexual reproduction by zoospores, rarely by non-motile spores......... ....*Saprolegniales.*
   B. Nonsexual reproduction by aerial conidia, which may give rise to zoospores; mycellium parasitic in higher plants.........*Peronosporales.*

THE TWO MAIN PHYLETIC BRANCHES OF THE MYCOMYCETÆ.

I. With ascospores, commonly 8 in an ascus; conjugate phase present, but usually not prominent. Here are included also all conidial types whose perfect stage is not known. ASCOMYCETOUS GROUPS.

II. With basidiospores, commonly 4, developed on a basidium; one prominent stage of the mycelium with two nuclei in each cell (conjugate phase); conidia sometimes produced, or spores of various types.
BASIDIOMYCETOUS GROUPS.

SYNOPSIS OF THE CLASSES AND ORDERS OF ASCOMYCETOUS FUNGI.

I. Asci developed after the conjugation of two cells of the mycelium, or parthenogenetically (?); occasionally fertilization by means of detached conidia-like spermatia; nonsexual conidia usually produced. Saprophytes or parasites on plants or animals, with an ordinary mycelium; many lichen fungi. In many species only the conidial form is known.
ASCOMYCETÆ. Sack Fungi.
- (I) Ascus stage known, conidial stage also commonly present.
  - A. Asci not in a definite fruiting body, with a variable number of spores or with a definite number.
    PROTO-ASCOMYCETÆ. Lower Sack Fungi.
    - 1. Plants developing a more or less typical mycelium.
      - a. Asci not arising from chlamydospores, (gemmæ), single or scattered, sometimes many-spored, thus resembling ordinary sporangia.......................... *Endomycetales*.
      - b. Asci arising from intercalary chlamydospores (gemmæ), ellipsoidal or elongated............ *Taphrinales* (Exoascales).
    - 2. No typical mycelium usually developed; asci entirely isolated; vegetative reproduction by budding of the cells; plants producing alcoholic fermentation.
      Saccharomycetales. Yeast Plants.
  - B. Asci with a definite number of spores, in typical cases commonly 4 or 8, collected on or in an ascocarp.
    - (A) Asci arranged at different levels in the fruiting body or fasciculate and surrounded by a spherical, cylindrical, pyriform, or shield-like wall which is commonly perforated at the top, but sometimes completely closed.
      - 1. Asci arranged at different levels in the fruiting body; or the hymenium lining cavities; mostly mold-like or tuber-like fungi. PLECTOMYCETÆ. Little Tuber Fungi.
        One order, *Aspergillales*.
      - 2. Asci in fascicles arising from a common level in a perithecium or cleistothecium or under a shield-like wall, mostly of a dark color. PYRENOMYCETÆ. Black Fungi.
        - (1) Saprophytes, or parasites on higher plants, not symbiotic with algæ.
          - a. Cleistothecia globose, scattered, without apparent ostiole in the top; superficial parasites in leaves, stems, etc. *Perisporiales*. Powdery Mildews.
          - b. Perithecia typically with a distinct ostiole; commonly situated in a stroma.
            - (a) Perithecia, and stroma if present, fleshy or membranous, bright-colored, as white, yellowish, red, or blue............ *Hypocreales*.
            - (b) Perithecia, and stroma if present, hardened, never fleshy, rarely membranous; dark-colored, as black or dark brown.
              - ((a)) Walls of the perithecia scarcely distinguishable from the stroma. *Dothideales*.
              - ((b)) Perithecia with distinct walls, either free or imbedded in a stroma. *Sphaeriales*.

(c) Perithecia membranous to leathery, long enclosed in a covering which ruptures by a radiating or stellate fissure or by a slit at maturity.

((a)) Perithecia rupturing by a stellate opening......................*Phacidiales.*

((b)) Perithecia opening by a slit. *Hysteriales.* Slit Fungi.

(2) Helotic fungi living symbiotically with algæ, forming lichens........................*Pyrenulales.*

(B) Asci collected in a flattened concave, convex, or irregular hymenial layer; fruiting body (ascoma) a disk-like or cup-like apothecium or at first closed and opening at maturity, the hymenial layer sometimes becoming pulverulent; sometimes prominently stalked......DISCOMYCETÆ. Disk Fungi.

1. Ascoma mostly elongated, or if round then becoming pulverulent, the spores and paraphyses forming a powdery mass.

a. Apothecia sphaeroidal, forming a powdery mass when mature, saprophytes or lichen fungi. *Caliciales.*

b. Apothecia linear, ellipsoidal or somewhat angular; lichen fungi symbiotic with algæ belonging to the Gonidiophyta.............*Graphidales.* Black Lichens.

2. Ascoma mostly round or irregular, not becoming pulverulent.

(1) Ascoma not permanently hypogaeous.

a. Lichen fungi with circular apothecia, symbiotic with algæ belonging to the Gonidiophyta and to the Cyanophyceæ....*Lecanorales.* Disk Lichens.

b. Ordinary fungi, sometimes large, with fleshy or leathery bodies, or in the simpler forms the fruiting body only slightly developed; ascoma at length becoming cup-shaped or saucer-shaped, or developing into a convex and sometimes pitted head on a stalk, some of the primitive forms merely developing a flat open plate.

(a) Asci inoperculate, opening by an irregular rupture at the tip, texture usually tough to leathery; spores mostly comparatively small or slender and often multicellular. *Geoglossales.*

(b) Asci operculate, opening by a definite lid or by a transverse or diagonal slit at the top; texture fleshy; spores comparatively large, unicellular..............*Pezizales.* Cup Fungi.

(2) Ascoma hypogaeous and fleshy, the hymenium lining cavities, permanently enclosed or finally opening. These plants show some resemblance to members of the Plectomycetæ and might belong to that series.. *Tuberales.* Truffles.

(II) Ascus stage not known, the hyphæ bearing conidia only and isolated conidial stages whose Asci are known; imperfect fungi with conidia superficial or in pycnidia, borne on loose innate hyphæ. A provisional subclass for conidial forms with uninucleate cells. DEUTEROMYCETÆ. Imperfect Fungi.

A. Conidia developed upon separate conidiophores which do not form a stroma; parasites and saprophytes.............*Moniliales.*

B. Conidia developed on a stroma; mostly saprophytes, a few destructive plant parasites.........................*Melanconiales.*

C. Conidia developed in pycnidia; parasites and saprophytes. *Sphaeropsidales.*

II. Asci developed after fertilization by means of a trichogyne and spermatium, no conidia known, but the spermatia sometimes conidium-like; minute fungi with a peculiar vegetative body parasitic on various insects, especially water beetles. LABOULBENIEÆ. Beetle Fungi.
- A. Sperm cells produced in closed antheridia............*Laboulbeniales*.
- B. Sperm cells produced like conidia, terminally or laterally on appendages..*Ceratomycetales*.

SYNOPSIS OF THE CLASSES AND ORDERS OF BASIDIOMYCETOUS FUNGI.

I. Basidia arising from teliospores; often other types of spores also produced; plant parasites, often heterecious; conjugate phase often prominently developed. TELIOSPORÆ. Brand Fungi.
- A. Teliospores usually black, not stalked, produced in ovularies, leaves, or stems of the host.
  - 1. Teliospores developing a nonseptate basidium which bears the spores at the apex...... ....*Tilletiales*. Stinking Smuts.
  - 2. Teliospores developing a several-celled or septate basidium which bears the spores at the sides of the cells . *Ustilaginales*. Smuts.
- B. Teliospores usually stalked, producing black or brown pustules under the epidermis of leaves or stems; often producing, on the same or on a different host, clusters of cup-like or crater-like aecia with spores formed in chains inside of a membranous pseudoperidium; other spore types may be present as uredospores and pycniospores. *Uredinales*. Rust.

II. Basidia produced directly on the vegetative mycelium, no proper teliospores being present, mostly saprophytes but some parasitic, especially on trees; often with massive fruiting bodies; conjugate phase prominently developed, with clamp-connections; terrestrial or epixylous; a few lichen fungi. Here are included the sterile mycelia known as mycorrhiza. BASIDIOMYCETÆ. Basidium Fungi.
- A. Basidia septate transversely or longitudually, or sometimes merely deeply two-forked; fruiting body mostly gelatinous; saprophytes. PROTOBASIDIÆ.
  - 1. Basidia with transverse septa..........*Auriculariales*. Ear Fungi.
  - 2. Basidia divided by diagonal or vertical septa. *Tremellales*. Jelly Fungi.
  - 3. Basidia long clavate, divided at the summit into two long sterigmata; spores divided before germination proper; mostly small saprophytes...............................*Dacryomycetales*.
- B. Basidia nonseptate.
  - 1. Basidia on a distinct membranous hymenium exposed from the beginning or at first covered and finally naked, covering gills, pores, spines, or a smooth or wrinkled surface; rarely parasitic and without a special fruiting body, the basidia then arising out of the epidermis of the host plant. HYMENOMYCETÆ.
    - a. Without a definite fruiting body.................*Exobasidiales*.
    - b. Usually with a definite fruiting body, the basidia on a distinct membranous hymenium, covering gills, pores, spines, or a smooth or wrinkled surface.....................*Agaricales*.
  - 2. Basidia enclosed within a definite peridium but sometimes exposed at maturity, the spores then borne in more or less deliquescent gleba. GASTEROMYCETÆ.
    - (1) Fruiting body not dehiscing in such a manner as to expose the hymenium by emerging from the peridium, nor developing sporangioles attached to the peridium wall with cords.
      - a. Fruiting body not developing a hyphal capillitium, but remaining fleshy until the spores are mature, or becoming pulverulent.
        - (a) Fruiting body large, tuberous, fleshy, subterranean, with internal hymenium which lines the walls of cavities...............*Hymenogastrales*. False Truffles.

(b) Fruiting body small to large, becoming pulverulent; basidia uniformly distributed through the fruiting body or forming skein-like masses.
Sclerodermatales. Thick-skinned Puff-balls.

b. Fruiting body, when mature, filled with dust-like spores mixed with the hyphal capillitium. *Lycoperdales*. Puff-balls.

(2) Fruiting body breaking open and the spore-bearing part or gleba emerging or else developing sporangioles, attached by threads to the wall of the peridium.

a. Fruiting body small, leathery, spherial or top-shaped developing sporangioles.....*Nidulariales*. Birds-nest Fungi.

b. Fruiting body fleshy, at first tuberous and subterranean, but later the spore-bearing interior or gleba emerging from the peridium by an elastically expanding stalk; usually ill-smelling..................*Phallales*. Stink-horns.

AN EXAMPLE OF SEDIMENTS DEFORMED BY ICE THRUST[1].

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Crumpling due to the drag of moving ice over more or less unconsolidated sediments has been described from various regions heretofore.[2] The present note desires to set on record a case of deformation in which the Ohio shale of the Devonian was one of the rocks affected and in which the method appears to have been actual shove by the ice-sheet at, or near, its front.

The exposure existed for several days in the pit of the Shale-Brick Company located in northeast Columbus. The deformed mass rested at the time against a solid wall of shale on the south and southeast, while to the north of the location there exists a valley in the shale, more than 50 feet deep, filled with chocolate clay of unknown depth overlain by drift up to 30 or more feet thick. The materials affected by the deformation included bedded shale at the base and weathered shale, chocolate clay, and drift above.

Two items merit notice: the direction of the ice thrust and the response of the materials to deformation. All observations at the time of the exposure indicated that the effective thrust of the ice came from the northwest. If local eddies of sharp outline could exist in ice as readily as in water the direction of ice thrust would arouse little comment. Topographic details of the underlying rock might deflect portions of the marginal ice, but to do so to the extent of 45 degrees or more and permit thrust sufficient to cause the observed deformation is doubtful.

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[1]Read before the Ohio Academy of Science, Springfield, April 27, 1929. The writer is indebted to Mr. John Stout, who directed attention to the exposure here described.

[2]Shaler, N. S. 1890. Tertiary and Cretaceous deposits of eastern Massachusetts. Bull. Geol. Soc. Amer., Vol. 1, 443–452.
Woodworth, J. B. 1897. Unconformities of Marthas Vineyard and of Black Island. Bull. Geol. Soc. Amer., Vol. 8, 197–212.
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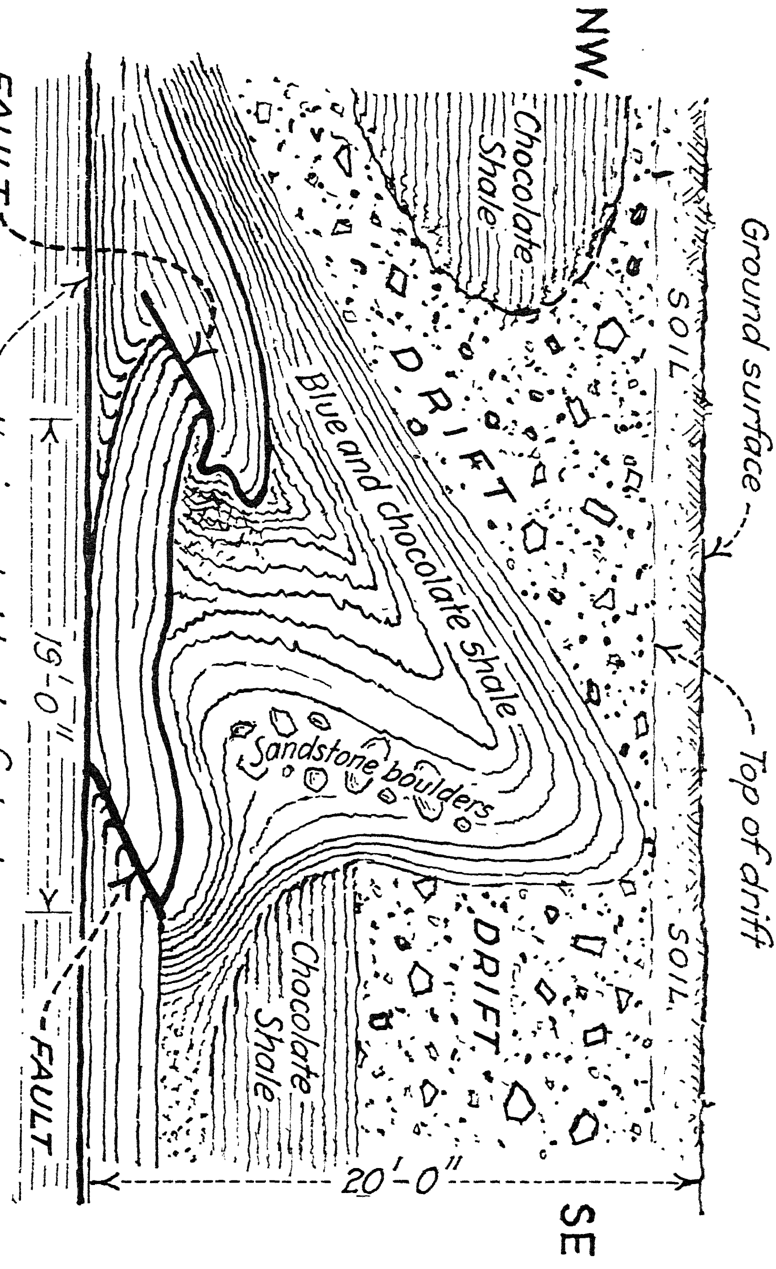

Structures produced by the thrust of an ice-sheet.

The northwest direction meets difficulty when the attempt is made to harmonize it with the character of the ice lobes and direction of ice movement as shown on plate V, monograph LIII[3] of the United States Geological Survey, especially in view of the geographic location of the deformed mass in relation to the axis of the Scioto-Olentangy basin. If the direction was typical of the given locality when the front of the ice stood there it would indicate that the Scioto lobe of the Wisconsin glacier deployed first over the western part of the Scioto basin and thence spread eastward. The axis of ice activity and advance, for a time at least, lay to the westward of the Scioto-Olentangy drainage axis, a condition favored by the topography of the basin whose cross-profile is asymmetrical in regard to a shorter and steeper eastern slope. The areal distribution of the Powell morainic belt likewise suggests a greater deployment of the ice in the western sector of the Scioto lobe.

However, the orientation of the deformed mass, the nature of the materials, and certain chemical criteria (striking variation in Ca CO_3 content) which cannot be detailed at present suggest that the deformation was accomplished by a pre-Wisconsin ice sheet. In this connection it is interesting to note Leverett's[4] reference to an Illinoian or possible pre-Illinoian advance apparently from the Lake Superior region.

The materials of the deformed mass reacted to the pressure in an interesting and characteristic fashion. The more competent beds at the base, the Ohio shale, yielded by fracture which resulted in three faults, two overthrusts and one underthrust. The less competent chocolate clays (labelled shale on the chart) were squeezed into an overturned fold with thinning on the limbs. The chocolate clays, which underlie the drift unless disturbed subsequent to formation, are an extremely tenaceous, gummy, apparently laminated material deposited in quiet waters near the bottom of a rock-walled valley. Cobbles scattered sparsely throughout the clay suggest transportation by means of floating ice.

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[3]Leverett, Frank. 1915. The Pleistocene of Indiana and Michigan and the history of the Great Lakes. U. S. Geol. Survey, Mono. LIII, Plate V.

[4]Ibid, 63–64.

DECEREBRATION OF THE DOMESTIC FOWL.

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The decerebration of the pigeon has been successfully accomplished by numerous investigators. Rolando (1809), Flourens (1822), Munk (1883), Shrader (1889), Rogers (1916 and 1922-23), and others have contributed much to our knowledge of the operative technique and the resultant behavior of the decerebrate bird. Rolando (1809) showed that decerebrate pigeons could be kept alive for a long period of time after extensive destruction of the cerebrum, the birds exhibiting a sleep-like attitude until they were destroyed.

Flourens (1822) decerebrated pigeons and chickens. After the result of his experimental work, he concluded that the seat of intelligence, will, etc., was in the cerebrum; that the senses, reception and conveying of the sense impressions were entirely separate; e.g. the sense of sight in the corpora bigemina. The decerebrate animal could not use its senses because it lacked perception.

In contrast to these workers Shrader (1889) stated, "None of my observation birds have showed longer than the first three or four days, that sleep-like attitude." He observed that decerebrate pigeons did not feed since this act apparently depended on portions of the frontal brain or perhaps on parts of the middle brain.

Munk (1883) studying the functions of the cerebral cortex of pigeons states, "I cannot agree with the oft repeated recommendation to use young animals. I have had the best success with older pigeons and finally used older ones for the experiment. * * * * * * * * * I must give warning against preparing the birds through long starvation and thirst to decrease hemorrhage, because as a result of such procedure the animal has not enough resistance and easily collapses from weakness. It is enough to keep nourishment away for eighteen hours."

The ability of an apparently decerebrate bird to regain the complex reflexes of eating and drinking was studied by Munk (1883) and Shrader (1889). These workers concluded that basal parts of the corpora striata were present. In a recent

work, Rogers (1922-1923) states, "The following basal areas of the striatum were demonstrated histologically to be present, though reduced in size; meso-striatum and parts of the ekto-striatum and epi-striatum. These parts were connected with the thalamus and mid-brain by medullated fibres which, after death, were readily stainable, and seemed histologically to be normal. These parts were present in one hemisphere only, only traces of the other hemisphere being present."

In the present series of decerebrations, the method of operative procedure closely followed that of previous workers, the technique being modified slightly as occasion demanded. Extended over a period of two years, fifty-four birds were operated removing the cerebral hemisphere partially or completely. Fowls were selected that were about one year of age and free from disease. These were placed in cages 20″ x 20″ x 12″, each bird having a separate compartment.

OPERATIVE PROCEDURE.

Birds were fasted eighteen to twenty-four hours before operating. The hen was secured in a cloth sack, leaving the head and neck protruding. Squibb's anaesthetic ether was used to anaesthetize the bird. Feathers were plucked from the operative area from ear to ear and from the comb posteriorly to the first cervical vertebra. A transverse incision was made through the skin from ear to ear and the periosteum removed from the bones covering the cerebral hemispheres. Two holes were trephined over the center of each hemisphere, and with small bone forceps the openings were enlarged from before backwards and from side to side, care being taken not to injure the dura mater, also carefully avoiding the longitudinal sinus. The dura mater was slit antero-posteriorly, after applying a solution of codrenin (cocaine 2% solution, with adrenalin 1-15000) to control hemorrhage. Using a small spatula the cerebral hemispheres were lifted, care being taken not to injure the brain stem. After the hemispheres were removed, hemorrhage was checked by using pledgets of cotton moistened with codrenin. The control of hemorrhage is more of a problem in fowls than in pigeons, due to the larger blood supply to these parts in the former. No attempt was made to suture the dura mater or the skin, in fact the latter was purposely left unsutured, so that the blood clot would not cause pressure upon basal centers. No ill results occurred from

infection, because of the high resistance that birds possess. Direct observations were not made until three or four weeks elapsed, thus giving time for the disturbed parts to heal.

Since the fowl could be completely decerebrated and continue in health for one month, the question arose, how long could a decerebrate bird live. Three operated fowls were selected, their behavior indicating complete decerebration. Since the eating and drinking reflexes were destroyed, food and water were administered by forced feeding to these birds daily. Two were observed over a period of four months, before being destroyed and autopsied. The third bird was kept in health for eight months, at which time it was attacked and killed by a rat, thus putting an end to the observation.

BEHAVIOR OF DECEREBRATE BIRDS.

The behavior of the birds depends entirely upon whether the birds are partially or completely decerebrate. Immediately after the operation and for two or three days all birds show more or less shock. After this period, if the bird is only partially decerebrate, eating and drinking may be accomplished with some difficulty, the bird pecking at food much the same as young chicks do. Completely decerebrate hens present the typical picture given by similarly operated pigeons; sleepy attitude, head and neck drawn into body, feathers fluffed, with occasional stretching of neck and legs. If enclosed in a small cage scarcely any movements occur for hours. Placed in larger quarters, the birds would sometimes stand motionless for variable lengths of time, then suddenly move several steps. Never do they fall over obstructions purposely put in their paths. There seemed to be more or less direct relation between restlessness and a state of hunger or thrist. Feeding and watering invariably put an end to the aimless wanderings, the birds assuming the sleeplike attitude so characteristic of the well-fed and watered decerebrate bird. Not infrequently these birds that have been fed and watered will arouse from lethargy, make a few restless movements, defecate, and again lapse into a somnolent attitude. Thus it appears that hunger, thirst and visceral impulses are the main factors which cause restlessness in the decerebrate bird. On the whole, birds evidence much more activity when given spacious quarters than when confined in smaller cages.

The thalamus was injured or destroyed in four birds producing such effects as were described by Rogers (1919-20). There was some variation in these birds, but he describes the picture essentially presented as follows: "The feathers lay somewhat against the body, instead of fluffed; no spontaneous

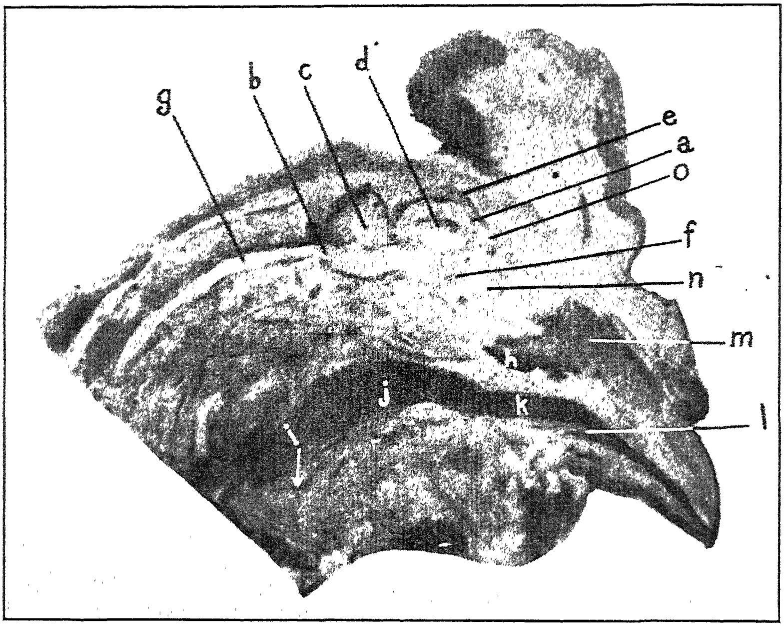

FIG. 1. Sagittal Section of the Head of Normal Birds.

a, cerebrum; b, medulla oblongata; c, cerebellum; d, lateral ventricle; e, dura mater; f, optic nerve; g, portion of cervical part of spinal cord; h, nasal cavity; i, arrow points to laryngeal opening; j, pharynx; k, oral cavity; l, tongue; m, septum nasi; n, medial portion of eye; o, olfactory bulb.

movements were made; body temperature was subnormal in three of the birds; stasis of food in the digestive tract; weakness; mucous membranes cyanotic; resting on tail feathers. Death followed in two or three days."

AUTOPSY OF DECEREBRATE BIRDS.

After the observations were made the decerebrate birds were embalmed with a 15% solution of formaldehyde, this being introduced into the left or right jugular vein, using a sixteen gauge needle and a 30 cc. syringe. The digestive tract and general condition of the birds were observed during post mortem. The heads were severed, placed in a solution of

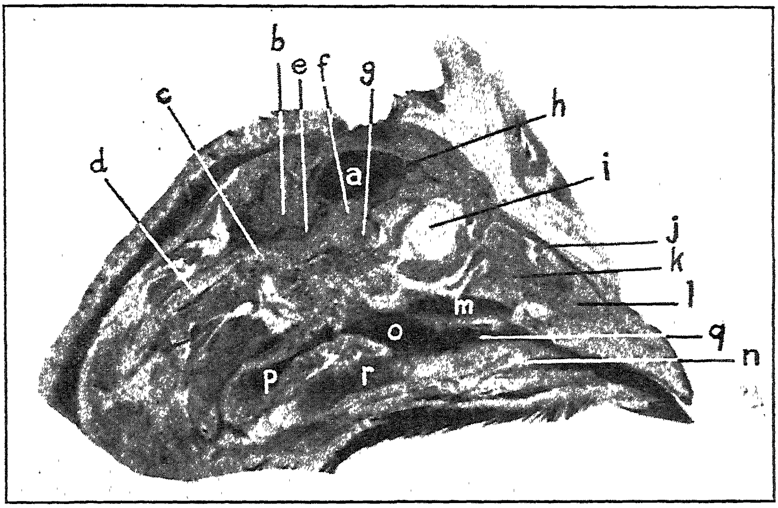

FIG. 2. Sagittal Section of the Head of Decerebrate Bird.

a, cerebral cavity; b, cerebellum; c, medulla oblongata; d, portion of cervical part of spinal cord; e, fourth ventricle; f, thalamus; g, optic nerve; h, dura mater; i, medial portion of eyeball; j, dorsal meatus; k, nasal septum; l, turbinate bone; m, posterior part of nasal cavity; n, tongue; o, pharynx; p, esophagus; q, oral cavity; r, larynx cranialis.

fuming nitric acid, one part of nitric acid to ten parts of water, and allowed to decalcify. In about ten days, the heads were sectioned and examined to determine definitely the areas of the brain tissue that had been extirpated. Figure I shows a saggital section of the head of a normal bird, while Figure II shows a section through the head of a decerebrate bird. The cavity enclosed by the dura mater in Figure II was filled with clear cerebral fluid, this cavity communicating with the third ventricle by way of the inter-ventricular foramen.

In the birds that showed typical decerebrate attitude, it was found that the cerebral hemispheres were entirely removed, with the exception of small areas which had no connection with the brain stem. In other birds that gave evidence of only partial decerebration there were found variable quantities of cerebral cortex, apparently uninjured. The connections with the brain stem appeared to be undisturbed. Those birds that could eat and drink showed only a partial removal of the corpora striata.

SUMMARY.

1. In decerebration of the fowl care must be taken to prevent severe hemorrhage.
2. Leaving the dura mater and skin unsutured relieves pressure on the vital centers.
3. Fowls were completely decerebrated and kept in health for periods varying from two to eight months, there seems to be reason to believe that this time could be extended indefinitely.
4. The behavior of decerebrate fowls closely follows that of the decerebrate pigeon.
5. Birds which regain complex reflexes of eating and drinking showed the corpora striata intact.

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PRELIMINARY EXPERIMENTS ON THE JUMPING REACTIONS OF MELANOPLUS DIFFERENTIALIS UHLER

RAY T. EVERLY.

The problem was to determine the environmental factors affecting the jumping reaction of *Melanoplus differentialis* Uhler, the Differential Locust. Specimens were secured in the fields of the vicinity of the Ohio State University, where the experiments were conducted in the summer of 1925. No one factor was worked to the exclusion of the others, but light seemed to be the strongest stimulus. Owing to the lack of adequate apparatus and the short period of time in which the hoppers were available, no definite conclusions can be drawn at this time. This report is made public now in order to make available the methods used and the results obtained to others who might be interested in this problem.

These experiments were conducted under the direction of Dr. W. M. Barrows, of the Department of Zoology and Entomology, Ohio State University, to whom I am indebted for criticisms and suggestions. A large amount of time was spent in assembling and designing the apparatus and correcting it to offset several difficulties.

The apparatus consisted of two main divisions, the jump recording apparatus and the time recording apparatus. The former consisted of a cone of white cardboard, about two feet high, (I), (see diagram of apparatus), open at the top, which was covered with a piece of clear celluloid, (J). The base was tightly closed and light-proof, and was fastened to the platform of a scale used for weighing letters, (H). (This type of scale was used because of it's high degree of sensitiveness). To the pointer of the scale was attached an arm, about 18″ long, (G), which had a pin fixed through the free end. This pin recorded the jumps on the paper, blackened over a coal oil lamp flame, on the rotating cylinder of the recording instrument, (F). This cylinder was revolved by clockwork making a complete revolution every 18 hours. The timing apparatus consisted of a dry cell battery, a clock, with the crystal removed, a ringstand, and an electro-magnet. The negative wire from

the battery, (A), was grounded to the clock, (B). The positive wire was connected to the insulated post on the electro-magnet. From the other post on the electro-magnet a wire was connected to the clamp, (E), which was supported on the same ring-stand, (D), as the electro-magnet. This clamp held a piece of stiff flexible wire, tilted at an angle upward so that the minute hand of the clock would make a contact with it on the hour, closing the circuit, and after a few minutes would force the wire up and break the circuit, the wire returning to its former position. A small pointer on the electro-magnet was moved when the circuit was closed, thus recording the hours on a line on the rotating cylinder just above the line on which the jumps were recorded.

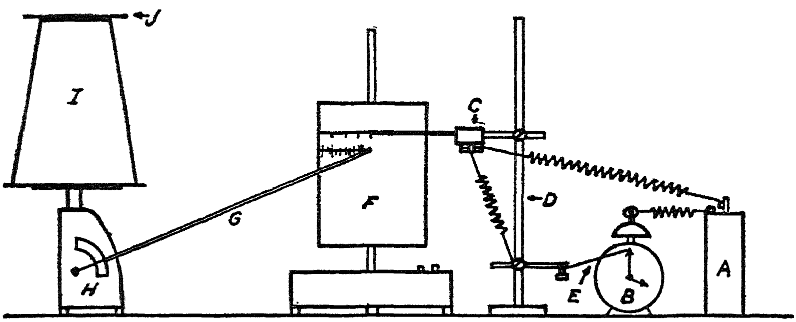

DIAGRAM OF APPARATUS

In all these experiments only one hopper was used at a time, and none were used for two successive periods. After 24 hours without food in the apparatus they were allowed a period of 24 hours for feeding and recuperation. Large cages were necessary as the grasshoppers confined in small ones were attacked and killed by the lawn ant, Lasius niger americana Em.

There were three types of experiments. First the insects were exposed to the diffused daylight in a room with an eastern exposure, about four feet from the window. No direct sunlight struck the insect. In this room there was a maximum variation of temperature of 12°F. occuring in the morning when the sun shone through the window. The humidity was rather constant, ranging from 43° to 50°F. in steps of 1°. The

following table shows the number of jumps per hour, correlated with the average temperature and average relative humidity, and light.

TABLE 1.

		P. M.												A. M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
4 Grasshoppers	Light	Diffused Daylight						Dark												Diffused Daylight					
	Jumps	7	12	3	6	10	15	27	46	3	1	1	6	2	1	0	0	1	2	4	11	19	16	18	17
	Av.° Hum.	43	43	44	44	44	44	45	46	46	47	48	48	48	48	49	49	49	49	50	50	50	49	49	49
	Av.° Temp.	76	76	75	75	75	75	75	75	75	74	74	74	74	74	74	74	73	73	73	74	74	85	77	75

The second type of experiment was run in the Department greenhouse, where there was a wide range of temperature and humidity, but the light was bright from 6:30 A. M. to 7 P. M. with perhaps a half hour of diffused light immediately preceding and following those hours. The changes in temperature were rather sudden, ranging from 89°F. to 62°F. Very little if any direct sunlight struck the insect or container as the glass was whitewashed to prevent destructive high temperatures. Table 2 shows the results obtained.

TABLE 2.

		P. M.												A. M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
3 Grasshoppers	Light	Bright Daylight						Diffused Daylight	Dark										Diffused Daylight	Bright Daylight					
	Jumps	15	15	16	4	3	0	4	7	3	1	1	1	3	0	0	0	0	0	0	0	0	0	3	7
	Av.° Hum.	49	43	46	48	50	53	57	62	66	68	69	69	69	69	70	71	71	71	73	74	75	67	50	45
	Av.° Temp.	80	80	82	80	78	76	75	73	71	70	69	68	67	66	65	65	63	63	64	64	65	70	77	82

The third type of experiment was conducted in a dark room where the temperature did not vary more than two degrees during any one period of 24 hours. However the

humidity was more variable, ranging from a variation of 4% in one experiment to 10% in the other. The light was supplied by a 40-watt Mazda lamp and was continuous. A record was kept of the sexes of the tested grasshoppers. Table 3 gives a comparison of the two sexes correlated with the temperature and relative humidity. The greater activity shown by the male does not necessarily indicate a difference in the activity of the two sexes as not enough of each sex were tested. It is natural to suppose that a greater activity would exist in

TABLE 3.

		P. M.												A. M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
	Light	40 Watt Mazda Lamp - Continuous																							
3 ♂ Grasshoppers	Tot. Jumps	17	23	24	23	16	19	12	10	19	10	13	18	12	7	17	14	12	10	8	8	1	7	0	0
	Av. Hum.	60	60	58	57	57	57	58	59	59	59	59	60	60	60	60	59	59	60	60	60	59	58	57	56
	Av. Temp.	75	75	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	77
3 ♀ Grasshoppers	Tot. Jumps	0	0	8	15	6	8	6	5	9	0	0	1	1	0	0	1	4	7	3	14	11	8	2	4
	Av. Hum.	53	54	57	57	58	57	57	57	57	57	58	58	58	58	58	58	58	58	58	58	58	59	63	65
	Av. Temp.	68	68	68	68	68	68	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69

the male sex, if there was any difference at all. Many studies of animal life, where the sexes are differentiated into two separate individuals, shows a decided difference of habits and a greater activity on the part of the male, which is the aggressor. Further experiments may proove that this is also true of the saltatorial reactions of the grasshopper.

One variation of the above experiment was tried. Two different intensities and qualities of light source were used. In both cases the light was continuous for a period of 24 hours. Table 4 shows the results, with the temperatures and relative humidity recorded.

There seems to be little if any difference with the two different lights. Jumping is almost continuous throughout the

experiments, with the exception of one hour. With the lower-powered light the activity is greater and the jumps are more evenly distributed throughout the entire period. This corresponds with the results recorded in Table 1, where the period of greatest activity occurs when the light is at a minimum intensity, just preceding sunrise and following sunset. The conflicting results in Table 2 may be due to the modifying action of the temperature and humidity. Further experimentation is necessary to prove or disprove this theory.

TABLE 4.

		P.M.												A.M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
4 Grasshoppers	Light	40 Watt Mazda Lamp - Continuous																							
	Jumps	17	23	32	39	33	33	19	18	29	11	14	24	18	11	21	17	17	19	14	26	17	22	8	14
	Av.° Hum.	53	53	54	53	54	53	54	55	55	55	56	57	57	57	57	57	57	57	57	57	57	57	58	59
	Av.° Temp.	71	71	78	78	79	79	72	72	72	72	72	72	72	72	72	72	76	76	76	71	76	76	76	75
4 Grasshoppers	Light	125 Watt Nitrogen Daylight Lamp - Continuous																							
	Jumps	24	22	22	10	16	16	14	18	24	14	18	38	8	14	20	10	6	6	0	16	16	8	14	16
	Av.° Hum.	65	64	65	66	66	66	67	67	67	68	68	68	68	68	68	67	67	67	63	61	61	62	64	65
	Av. Temp.	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	73	73	73	73	73	73

Table 5 shows the comparison of the reactions of the grasshoppers to natural daylight and those tested with artificial light. The average temperatures and average relative humidity are also recorded. The variation of jumps per hour is much greater under natural light than under artificial light, which is to be expected as there is a greater variation of the former during the different hours of the day, especially toward night and early in the morning. The rays at these periods are more or less horizontal and must penetrate more of the atmosphere, which tends to change the quality and intensity of light by filtering out some of the rays. It would be interesting

to test out the different colors of the spectrum to determine which rays have the greatest effect on the grasshoppers.

SUMMARY

As stated previously no definite conclusions may be drawn from the limited number of experiments performed. However, the results obtained permit of certain deductions.

TABLE 5.

		P.M.												A.M.											
Hours		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
8 Grasshoppers	Light	← Daylight →								← Dark →									← Daylight →						
	Jumps	22	27	19	10	13	15	34	54	6	2	2	7	5	1	0	0	1	2	4	11	19	16	21	24
	Av. 8 Hum.	46	43	45	46	47	49	49	54	56	58	59	59	59	59	60	60	60	60	61	62	62	62	50	47
	Av. 8 Temp.	78	78	78	78	77	76	75	74	73	72	71	71	71	70	69	69	68	68	68	69	69	77	77	78
8 Grasshoppers	Light	← Continuous Light →																							
	Jumps	35	42	54	67	41	46	40	30	50	20	27	46	23	17	34	25	25	26	16	39	26	26	13	17
	Av. 8 Hum.	58	58	58	58	59	58	59	59	59	60	60	61	61	61	61	60	60	60	59	59	59	59	60	61
	Av. 8 Temp.	72	72	73	73	73	73	73	73	73	73	73	73	73	73	73	73	74	74	74	72	74	74	74	74

NOTE. All humidities recorded are relative.
All jumps recorded are totals for the individuals tested which tends to balance differences in individualistic behaviour.

1. Light appears to be the strongest stimulus. In Table 5 it will be seen that the hoppers exposed to continuous light showed not only a greater activity, but the jumps were more or less evenly distributed over the entire period of 24 hours. Those exposed to daylight alone showed the period of maximum activity during the daylight hours. Comparison of the hours from 8 P. M. to 6 A. M. gives support to the supposition that jumping is a light response. Casual observation of grasshoppers in their natural habitat also lends support to the theory that light or other visual stimuli are the chief stimuli.

In the evening when the light is less intense a greater activity was observed among the different species of grasshoppers. This may be due to both the intensity and quality of the light, as well as the direction.

2. Heat, in these experiments, does not appear to affect the jumping. In Table 2, as stated before, heat may be responsible for the conflicting results recorded, so modifying the activity that the greater number of jumps were recorded when the light was more intense. In Tables 1 and 3 the greatest activity was shown when the light was less intense.

Work by Geist on the heat sensitive areas of certain grasshoppers showed, in this species, a period of continuous jumping when the surface upon which the grasshopper rested was heated to a temperature high enough to raise the air temperature to 37°C.—about 98°F. This was undoubtedly due to stimulation from the surface upon which they were resting. Whether the same would also be true if only the surrounding air only were heated, is a question to be decided by further experimentation. However, such temperatures do not as a rule occur in the natural habitat of this species of grasshopper.

3. Sex may play an important part in the difference displayed in the activity of different individuals. Table 3 shows a greater number of jumps recorded for the male of the species, as would natuarlly be supposed to be the case.

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AN ECOLOGICAL STUDY OF THE SPIDERS OF THE BEECH-MAPLE FOREST.*

FRANK R. ELLIOTT.

INTRODUCTION.

The members of the order Araneæ have been studied extensively in several sections of North America by a number of students of the group including Walckenaer, McCook, Emerton, R. V. Chamberlin, Banks, Petrunkevitch, Peckham, Barrows, Crosby, Bishop and others with the result that now new species of spiders are of little more frequent report than new species of insects in many of the orders.

Works of a non-taxonomic nature dealing with seasonal succession and abundance, migration, hibernation, quantitative relations etc. have had to do with the entire population or a rather large group (Adams 1915), (Holmquist 1926) in an association such as Prairie (Adams 1915), Coniferous forest (Sanderson and Shelford 1922), (Adams 1920), (Blake 1926) or Deciduous forest (Shelford 1912, 13) (Adams 1915) (Weese 1924), (Blake 1926).

The study here considered is that of the Beech-Maple forest and is limited to an intensive consideration of the Spiders. These are here discussed from two view points; Taxonomic, having to do with the species present in the beech-maple forest and Ecological, involving a discussion of the species present as to specificity for the habitat, hibernation, migration, annual and seasonal cycle, and various other ecological aspects.

An eighty acre Beech-Maple forest, known as Lewis Woods, located in extreme eastern Indiana, near Richmond, was selected as a restricted area for intensive observation and collection. This area is a rectangular tract 80 by 160 rods, heavily wooded with beech and sugar maple on the upland

*Contribution No. 96 from the Department of Zoology and Entomology, Ohio State University.

portion with admixture of some ash, and an occasional buckeye and linden on lower levels. This forest had not been pastured for thirty-five years and then only occasionally nor had any timber been removed from it during that time except the removal of a few beech trees over an area of about three acres near each end, about three years ago. This forest is the Beech-Sugar mesophytic forest typical of well drained physiographically mature soils (Sears 1926) and doubtless a typical primary association, and being unmodified by activity of man well represents a close approximation to primitive forest conditions. Its spider population is doubtless similarly typically representative.

Collecting was by beating branches and small trees, sweeping herbs and bushes, sifting leaves, humus and upper soil layer and the removal of bark and wood of dead trees, logs, woodpiles and stumps.

Collections and observations were made in other Beech-Maple forests in Indiana and Ohio with results which coincided with those obtained in the selected environment.

The account of the Spiders is given as follows: (a) The beech-maple forest as a habitat and the interrelation of the physical and biotic factors (b) species, genera, and families of spiders present (c) the distribution of the spiders in the beech-maple association (d) the annual and seasonal succession (e) migration and hibernation (f) the specificity of the species present for the association and (g) the representation of each species and the relation of the principal species to the total spider population.

I am very much indebted to Dr. W. M. Barrows of the Department of Zoology of Ohio State University for valuable suggestions, assistance in the determination of the species and the loan of literature.

The Beech-Maple Forest as a Habitat.

The beech-maple forest like that of the deciduous forest in general presents a well stratified habitat with more uniform conditions for any period of the year than those in other associations such as the low arctic tundra, prairie, heath, etc. This is in part due to the absence of alpine conditions and in large measure to the influence of the forest cover itself. The marked physical feature is the constancy and sharpness of the strata, this being correlated with and primarily caused by

stratification of plant societies. The principal strata are Forest floor, Herb, Shrub and Bush and the Forest cover.

The forest floor is a level of low but constant temperature, high moisture, minimum evaporation, scant light, rather constant population except in winter when increased by migrants. The predominant animals are those suited to considerable moisture, fairly low summer temperature and minimum light.

From the forest floor to the herb stratum occurs the steepest gradient in the series for the physical factors. Animals going from the ground floor to the herb stratum undergo pronounced changes in the physical environment. The population of this stratum is larger and more varied than that of any other stratum.

Shrub and Bush and Forest cover present differences of the same character as those between forest floor and herb strata but of much less magnitude and of less decisive character.

Examination of the population of the forest shows that it exhibits rather definite divisions into stratal societies. A further study (Weese) brings out an existing correlation between the physical and biotic differences of the successive strata. These two forces are of different importance at different periods of the annual cycle, the physical factors becoming markedly of greater importance at seasonal periods. This is very clearly evidenced in the beech-maple forest in the case of spiders by changing distribution in the autumn and spring.

During spring, summer and fall the animal population of the forest falls into stratal societies which are in general in agreement with the stratification of physical factors and vegetation. This would seem to be of direct value to the plant eating forms, but since even they respond to the physical factors by stratum to stratum migration, and as stratification occurs also among such animals as spiders which possess no relations with the vegetation it would seem that the physical factors are important and decisive (Blake 1926). A considerable number of species of spiders habitually pass between herb and shrub strata while a much smaller number divide their activity between ground and herb strata. The tendency seems to be for animals to make traverse only between strata which are separated by moderate gradients.

Weese (1924) gives evidence that the lower temperature fluctuations of fall serves as a stimulus causing beetles to migrate first into the interior of the forest then downward into the lower strata for hibernation. The downward migra-

tion of both young and adults of many herb and shrub inhabitating spiders is a distinctive characteristic of the group, more than half of the species here found doing so, and is in all probability a definite response primarily to changing temperatures. Vertical shifting, community stratification and other distribution of spiders though of less extreme character are in all probability largely gradational responses to changing biotic and physical conditions.

The Spiders Occurring in Beech-Maple Forest.

The name given to each spider is that listed in the Synonymic Index-Catalogue of Spiders of North, Central and South America (Petrunkevitch). The Synonomy is also largely based on the same. No attempt is made to give a complete synonomy but merely to list the principal other names by which a spider has been described by leading Arachnologists, principally Blackwall, Chamberlin, Emerton, Hentz, Keyserling, McCook, Peckham, Simon, and Walckenaer, to the end that it may best serve the needs of those having recourse to any of these works. In most cases the name listed is that by which the individual is best known. In some instances, however, a spider is best known by some synonym and will be most frequently described by American students under such. Confusion resulting from the nomenclature given however is compensated by advantages accruing from adherence to the rule of priority. The arrangement of the families and genera is that given in Systema Aranearum, by the same author. The species are for convenience numbered from one to ninety-nine.

Family **Dysderidæ.**

1. *Ariadne bicolor* Hentz. Same Emerton-Simon; *Pylarus bicolor* and *pumulis* Hentz.

Family **Amaurobidæ.**

2. *Amaurobius americana* Emerton. *Titanoeca americana* Emerton-Banks; *Titanoeca brunnea* Emerton.
3. *Amaurobius bennetti* Blackwall. Same Banks; *Ciniflo benneti* Blackwall; *A. sylvestris* Emerton-Simon.

Family **Agelenidæ.**

4. *Agelena naevia* Walckenaer. Same Hentz-Emerton; *Agelena peninsulana* C. Koch; *Agelena potteri* Blackwall; *Agelena americana* Keyserling.
5. *Cicurina arcuta* Keyserling. Same Simon; *Cicurina complicata* Emerton.
6. *Cicurina brevis* Emerton. Same Banks; *Tegenaria brevis* Emerton; *Cicurina creber* Banks.
7. *Cicurina pallida* Keyserling. Same Emerton.
8. *Coelotes hybridus* Emerton.

9. *Coelotes longitarsus* Emerton. *Coelotes gnavus* Banks.
10. *Coelotes montanus* Emerton.
11. *Coras medicinalis* Hentz. Same Emerton-Simon. *Teneraria medicinalis* Hentz; *Coelotes medicinalis* Emerton; *Coelotes urbanus* Keyserling.
12. *Hahnia agilis* Kerserling. *Hahnia bimaculata* Emerton.
13. *Hahnia cinerea* Emerton.
14. *Hahnia radula* Emerton. Same Simon.

Family **Pisaurinidæ.**

15. *Pisaurina mira* Walckenaer. Same Montgomery; *Dolomedes mirus* and *virgatus* Walckanaer; *Micrommata undata, serrata, caroliensis* and *marmorata* Hentz; *Pisaurina undata* Banks; *Ocyale undata* Emerton-Montgomery; *Dolomedes binotatur* C. Koch.
16. *Dolomedes fontanus* Emerton. Same Montgomery; *Dolomedes tenebrosus* Emerton-Hentz.

Family **Lycosidæ.**

17. *Allocosa funerea* Hentz. Same Chamberlin; *Lycosa funerea* Hentz; *Lycosa* and *Trochosa sublata* Montgomery.
18. *Lycosa gulosa* Walckenaer. Same Chamberlin; *Lycosa kochii* Emerton; *Lycosa purcelli, nigraurata, euepigyrata* and *insopita* Montgomery; *Trochosa purcelli* Montgomery; *Tarentula pulchra* Keyserling; *Lycosa pulchra* Chamberlin.
19. *Lycosa rabida* Walckenaer. Same Banks; *Lycosa scutulata* Hentz-Emerton-Montgomery-Chamberlin.
20. *Schizocosa crassipes* Walckenaer. Same Petrunkevitch; *Lycosa crassipes* Walckenaer; *Lycosa ocreata* Hentz-Keyserling-Emerton-Chamberlin; *Lycosa rufa* Kerserling; *Lycosa stonei* Montgomery; *Pardosa solivaga* Montgomery.
21. *Pirata febriculosa* Becker. *Lycosa febriculosa* Becker-Chamberlin; *Lycosa wacondana* Scheffer; *Pirata sedentarius* Montgomery.

Family **Dictynidæ.**

22. *Dictyna foliacea* Hentz. Same Banks; *Theridium foliaceum* Hentz; *Theridium roscidum* Hentz; *Theridion hypophyllum* Fitch; *Dictyna volupis* Keyserling-Emerton; *Dictyna dubia* Banks.
23. *Dictyna minuta* Emerton.
24. *Dictyna sublata* Hentz. Same Banks; *Theridion sublatum* and *morologum* Hentz; *Dictyna sedentaria* and *foliata* Keyserling; *Dictyna muraria* Emerton.
25. *Lathys foxii* Marx. Same Banks-Simon; *Prodalia foxii* Marx.
26. *Lathys pallida* Emerton. Trans. Conn. Acad. Sci., Vol. IX, 1894, new.

Family **Theridiidæ.**

27. *Pedanostethus pumulus* Emerton. Supplement New Eng. Spiders, Jan., 1909, Vol. 14, p. 183. Described as new.
28. *Crustulina guttata* Wider. Same Simon; *Theridion guttata* Wider; *Steatoda guttata* Emerton; *Crustulina sticta* Keyserling.
29. *Steatoda borealis* Emerton. Same Keyserling; *Theridion borealis* Hentz.
30. *Euryopis funebris* Hentz. Same Emerton-Keyserling-Simon-Banks; *Theridion funebre* Hentz.
31. *Theridion differens* Emerton. Same Keyserling.
32. *Theridion frondeum* Hentz. Same Emerton-Keyserling-Simon-Cambridge.
33. *Theridion pennsylvanicum* Emerton. Bulletin Am. Mus. Nat. Hist., Vol. XXXII, New and Rare Spiders Fifty Miles of New York.
34. *Theridula opulenta* Walckenaer. Same Simon-Cambridge-Hentz; *Theridula sphaerula* Emerton-Keyserling; *Theridion sphaerulum* Hentz; *Theridion gonygaster* Simon; *Theridula triangularis, quinqueguttata* and *quadripunctata* Keyserling; *Theridion ventillaris* Keyserling.

Family **Linyphiidæ.**

35. *Bathyphantes micraria* Emerton. Same Banks.
36. *Bathyphantes nigrinus* Westring. Same Simon; *Linyphia nigrina* Westring-Emerton; *Linyphia pulla* Blackwall; *Diplostyla nigrina* Emerton.

37. *Bathyphantes zebra* Emerton. Same Banks.
38. *Linyphia clathrata* Sundevall. Same Emerton-Simon; *Linyphis multiguttata* Ruess; *Linyphia luctuosa* C. Koch; *Nereine marginata* Blackwall; *Frontina clathrata* Keyserling.
39. *Linyphia conferta* Hentz. nec *L. conferta* Banks; nec *Floronia conferta* Banks.
40. *Linyphia marginata* Emerton. Same C. Koch-Simon-Keyserling; *Linyphia triangularis* Walckenaer-Blackwall; *Linyphia marmorata* Hentz.
41. *Linyphia phrygiana* C. Koch. Same Emerton-Simon-Keyserling; *Linyphia costata* Hentz.
42. *Microneta cornupalpis* Cambridge. Same Emerton-Banks-Simon; *Erigone cornupalpis* Cambridge.
43. *Ceraticelus minutus* Emerton. Same Crosby; *Ceratinella minuta* Banks-Emerton.
44. *Ceratinella brunnea* Emerton. Same Crosby; *Ceraticelus brunnea* Simon.
45. *Gongylidiellum pallidum* Emerton. Same Crosby; *Tmeticus pallidus* Emerton; *Erigone pallescens* Marx.
46. *Oedothorax montiferus* Emerton. Same Crosby; *Lophocarenum montiferum* Emerton. *Nereine montifera* Simon.
47. *Oedothorax platyrhinus* Crosby. See Journal New York Ent. Soc., Vol. XXXV, June, 1927—C. R. Crosby and Sherman C. Bishop.
48. *Oedothorax probatus* Cambridge. Same Crosby; *Erigone probata* Cambridge-Keyserling; *Tmeticus probatus* Emerton.
49. *Prosopotheca minuta* Emerton. Same Crosby-Simon; *Cornicularia minuta* Emerton; *Erigone paullula* Marx.
50. *Tmeticus aestivalis* Emerton. Trans. Conn. Acad. Sci., Vol. 16, 1911. New Spiders New England. Described as new.
51. *Ceratinopsis interpres* Cambridge. Same Emerton-Crosby; *Erigone interpres* Cambridge-Keyserling; *Notionelli interpres* Banks.
52. *Diplocephalus exiguus* Banks. Same Crosby; *Lophocarenum exiguum* Banks.
53. *Trachelocamptus rostratus* Emerton. Same Simon-Crosby. *Lophocarenum rostatum* Emerton.

Family **Uloboridæ.**

54. *Uloborus americana* Walckenaer. Same Cambridge; *Uloborus plumipis* Lucas-Emerton-Simon-McCook; *Uloborus villosus* Keyserling; *Phillyra manneata* and *riparia* Hentz.
55. *Hyptiotes cavatus* Hentz. Same Emerton-Simon-McCook; *Cyllopodia* Hentz; *Hyptiotes americanus* Wilder.

Family **Argyropidæ.**

56. *Acacesia foliata* Hentz. Same Simon-F. Cambridge; *Epeira foliata* Emerton-Hentz-McCook; *Epeira folifera* Marx.
57. *Araneus angulatus* Clerck. *Araneus virgatus* Clerck; *Epeira angulata* C. Koch-Simon-Emerton-McCook-Keyserling; *Epeira bicentenaria* McCook.
58. *Araneus arabesca* Wlackenaer. *Epeira arabesca* Walckenaer-McCook. *Epeira mutabilis* Walckenaer; *Epeira trivittata* Keyserling-Emerton; *Neoscona arabesca* F. Cambridge.
59. *Araneus arenatus* Walckenaer. *Epeira verrucosa* Hentz-Emerton. *Verrucosa arenata* McCook-F. Cambridge; *Mahadeva verrucosa* and *reticulata* Keyserling.
60. *Areneus ectypus* Walckenaer. *Epeira infumata* Hentz-Emerton. *Wixia ectypa* Keyserling-McCook; *Wicia infumata* Banks; *Epeira ectypa* Walckenaer-Keyserling.
61. *Araneus marmoreus* Clerck. *Araneus gigas conspicellata* Comstock; *Epeira insularis* Hentz-Keyserling-Emerton; *Epeira marmorea* C. Koch-Simon-Emerton-McCook; *Epeira scalaris* Walckenaer-Blackwall; *Epeira conspicellata* McCook-Walckenaer; *Epeira obesa* Hentz.
62. *Eustala anastera* Walckenaer. Same Simon-F. Cambridge; *Epeira bombicinaria* Hentz; *Epeira prompta* Hentz; *Epeira parvula* Emerton-Keyserling; *Epeira anastera* McCook.
63. *Mangora gibberosa* Hentz. *Epeira gibberosa* Hentz-Emerton-Keyserling; *Abbotia gibberosa* McCook; *Mangora gibberosa* Simon.

64. *Ordgarius bisaccatus* Emerton. Same Keyserling-McCook; *Glyptocranium bisaccatum* Emerton; *Epeira multilineata* Atkinson; *Cyrtarachne bisaccatum* Emerton.
65. *Leucauge venusta* Walckenaer. Same F. Cambridge; *Epeira venusta* Walckenaer; *Epeira hortorum* Hentz; *Argyroepeira hortorum* Emerton-Keyserling-McCook-Simon. *Tetragnatha quinquelineata* Keyserling; *Linyphia aurulenta* Walckenaer-C. Koch.
66. *Tetragnatha laboriosa* Hentz. Same Keyserling-Emerton-Banks-McCook; *Tetragnatha fluviatilis* Keyserling; *Tetragnatha illinoioensis* Keyserling.
67. *Micrathena gracilis* Walckenaer. Same, F. Cambridge-Simon; *Plectana gracilis* Walckenaer; *Acrosoma matronale* C. Koch; *Epeira rugosa* Hentz; *Acrosoma rugosa* Emerton; *Acrosoma gracilis* McCook; *Micrathena matronalis* McCook.
68. *Micrathena sagittata* Walckenaer. Same, Simon-F. Cambridge; *Plectana sagittata* Walckenaer; *Epeira spinea* Hentz; *Acrosoma bovinum* Thorell; *Acrosoma spinea* Emerton; *Acrosoma sagittata* McCook.

Family **Mimetidæ.**

69. *Ero furcatus* Villers. Same Simon-Keyserling; *Aranea furcata* Villers-Simon; *Ero variegata* C. Koch; *Theridion variegatum* Walckenaer-Blackwall; *Theridion leoninum* Hentz; *Ero thoracica* Thorell-Emerton.

Family **Drassidæ.**

70. *Herpyllus vasifer* Walckenaer. Same Simon; *Drassus vasifer* Walckenaer-Blackwall; *Herpyllus ecclesiasticus* Hentz; *Prosthesima propinqua* Keyserling; *Prosthesima ecclesiasticus* Emerton.
71. *Nodocion* sp.
72. *Sergiolus variegatus* Hentz. Same Emerton-Simon; *Herpyllus variegatus* Hentz; *Poecilochroa variegata* Emerton.
73. *Zelotes ater* Hentz. *Herpyllus ater* Hentz; *Prosthesima melancholica* Thorell; *Prosthesima funesta* Keyserling; *P. atra* Emerton; *Melanophora atra* Simon.

Family **Thomisidæ.**

74. *Philodromus minutus* Banks. *Philodromus brevis* Emerton; *Philodromus minusculus* Banks.
75. *Misumenops asperatus* Hentz. Same Emerton-Banks; *Misumena rosea* Keyserling-Banks; *misumena foliata* Banks; *Misumena placida* Banks; *Thomisus asperatus* Hentz.
76. *Misumenops oblongus* Keyserling. *Misumena oblonga* Keyserling-Emerton; *Misumessus oblongus* Banks.
77. *Oxyptilus monroensis* Keyserling. Same Banks.
78. *Tmarus* sp.? Probably *angulatus* Walckenaer; *Tmarus caudatus* Emerton-Keyserling; *Tmarus rubromaculatus* Keyserling; *Thomisus caudatus* Hentz.
79. *Xysticus ferox* Hentz. Same Banks; *Xysticus stomachosus* Keyserling-Emerton; *Thomisus ferox* Hentz.
80. *Xysticus fraternis* Banks. (Spiders of Long Island).
81. *Xysticus nervosus* Banks. Same Emerton.

Family **Clubionidæ.**

82. *Clubiona obesa* Hentz. Same Banks. *Clubiona crassipalpis* Keyserling-Banks-Emerton; *Clubiona mixta* Emerton.
83. *Clubiona pallens* Hentz. *Clubiona excepta* L. Koch-Emerton.
84. *Anyphaena pectorosa* L. Koch. *Anyphaena calcarata* Simon-Emerton; *Gayenna calcarata* Banks.
85. *Anyphaena saltabunda* Hentz. Same Emerton-Simon; *Clubiona saltabunda* Hentz.
86. *Phrurolithus alarius* Hentz. *Phrurolithus borealis* Emerton, Trans. Conn. Acad. Sci. '11; *Herpyllus alarius* Hentz; *Phrurolithus palustris* Banks, in Spiders Cayuga Lake Basin, '92.

87. *Phrurolithus palustris* Banks. *Phrurolithus borealis* Emerton. See Notes on the Spiders of Southeastern United States by S. C. Bishop and C. R. Crosby, Journal Elisha Mitchell Scientific Society, Vol. 41, Nos. 3 and 4, April, 1926.
88. *Phrurolithus similis* Banks. Spiders Long Island.
89. *Trachelas tranquillus* Hentz; *Trachelas ruber* Keyserling-Emerton-Simon; *Clubiona tranquilla* Hentz-Banks; *Agelena plumbea* Hentz.
90. *Castaneria cingulata* C. Koch. *Castaneria bivittata* Keyserling; *Goetrecha bivittata* Emerton; *Thargalia bivittata* Banks; *Herpyllus zonarius* Hentz; *Spargassus cingulatus* Walckenaer; *Corinna cingulata* C. Koch.
91. *Castaneria longipalpus* Hentz. Same Banks; *Castaneria pinnata* Bryant; *Herpyllus longipalpus* Hentz; *Thargalia longipalpus*, *perplexa* and *pinnata* Banks; *Geotrecha pinnata* Emerton.

Family **Attidæ.**

92. *Synemosyna formica* Hentz. Same Emerton-Simon-Peckham; *Janus gibberosa* C. Koch.
93. *Maevia vittata.* Same Emerton-Simon-Peckham; *Attus vittatus* Hentz; *Attus niger* Hentz; *Plexippus undatus* C. Koch; *Maevia annulipes* C. Koch; *Astia vittata* Peckham.
94. *Habrocestum pulex* Hentz. Same Simon-Peckham; *Saitis pulex* Emerton-Peckham; *Saitis x-notata* Keyserling; *Cyrba pulex* Keyserling; *Attus pulex* Hentz; *Euophrys offuscata* C. Koch.
95. *Dendryphantes (Phidippus) audax* Hentz; *Attus audax* Hentz; *Attus tripunctatus* Hentz-Peckham; *Phidippus tripunctatus* Emerton; *Phidippus audax* Peckham; *Phidippus dubiosus* C. Koch.
96. *Dendryphantes capitatus* Hentz. Same Peckham; *Attus capitatus*, *hebes*, *parvus* and *octavus* Hentz; *Dendryphantes aestivalis* Emerton; *Dendryphantes insignis*, *ornatus* and *exiguus* Banks; *Dendryphantes octavus* Simon.
97. *Dendryphantes (Phidippus) clarus* Keyserling. *Phidippus insolens* Peckham; *Phidippus multiformis* Emerton-Peckham; *Phidippus minutus* and *princeps* Banks; *Phidippus clarus* Peckham.
98. *Icius hartii* Emerton. Same Banks-Peckham.
99. *Neon nelli* Peckham. Same Emerton-Simon; *Icius obliquus* Banks.

Distribution of the Spiders in the Association.

With the advent of spring and the first emergence of vegetation above the forest floor there is a marked increase in the activity of the spiders. As the season advances there is evidenced a pronounced different distribution of the species which becomes more and more marked. A number of the young and adults of species that have been present throughout the winter and newly hatched young of other species remain in the ground floor. Many of the species however definitely leave the forest floor not to reenter it again until the approach of winter.

The upward migration with most species extends but a few feet, the spiders being distributed on the low herbage, vines and shrubs. A few of the species however go well up into the trees. This is especially true of Araneus ectypa, Hyptiotes cavatus, Micrathena sagittata, Araneus arenatus, Philodromus minutus and Ordgarius bisaccatus. No attempt

was made to study carefully the forest cover to determine the number and kinds of spiders present in the same. Three groups only have been considered, Ground floor forms, Ground-Vegetation forms and Vegetation forms.

In Beech-Maple forest the separation of the vegetation into Herb stratum and Shrub stratum with reference to spiders cannot well be made as has been done in Elm-Maple (Weese) for the animal population in general. Almost without exception spiders thought to be of the herb stratum were found frequently in the shrub stratum. In addition all of the species listed as shrub forms for Elm-Maple (Weese) were in beech-maple found repeatedly in both shrub and herb stratum. In beech-maple forest differences in the physical factors, light, evaporation, humidity, temperature, etc. of the herb and shrub strata are apparently not great enough to bring about a stratification of the spider community.

The distribution of beech-maple spiders is here presented. The following forms were not listed in the groups, Allocosa funerea, a typical grassland form; Bathyphantes nigrinum, a typical grassland spider; Herpyllus vasifer, lives under bark; Ordgarius bisaccatus, a tree form; and Trachelas tranquillas, more typically a transitional or field form. The remaining species are as follows.

I. Ground Stratum Forms.

Forest floor spiders inhabiting leaves, humus and upper soil layer throughout the year.

Amaurobius americana
Amaurobius bennetti
Ariadne bicolor
Bathyphantes zebra
Castaneria cingulata
Castaneria longipalpis
Ceratinella brunnea
Ceraticelus minutus
Cicurina arcuata
Cicurina brevis
Cicurina pallida
Coelotes hybridus
Coelotes longitarsus
Coelotes montanus
Coras medicinalis
Crustulina guttata
Diplocephalus exiguus
Ero furcatus
Gongylidiellum pallidum
Hahnia agilis
Hahnia cinerea
Hahnia radula
Lathys foxii
Lathys sp. (*pallida?*)
Neon nellii
Nodocion sp.
Oedothorax platyrhinus
Oedothorax montiferus
Oedothorax probatus
Oxyptila monroensis
Pedanostethus pumulus
Phrurolithus alarius
Phrurolithus palustris
Phrurolithus similis
Prosopotheca minuta
Schizocosa crassipes
Tmeticus aestivalis
Trachelocamptus rostratus
Xysticus ferox
Xysticus fraternus
Zelotes ater

II. Ground-Herb-Shrub Forms.

Agelena naevia	*Habrocestum pulex*
Anyphaena saltabunda	*Linyphia clathrata*
Clubiona obesa	*Lycosa gulosa*
Clubiona pallens	*Lycosa rabida*
Dendryphantes capitatus	*Maevia vittata*
Dendryphantes (Phid.) audax	*Microneta cornupalpis*
Dendryphantes (Phid.) clarus	*Pisaurina mira*
Dictyna foliacea	*Pirata febriculosa*
Dictyna minuta	*Sergiolus variegatus*
Dictyna sublata	*Synemosyna formica*
Dolomedes fontanus	*Xysticus nervosus*

III. Herb-Shrub Forms.

Acacesia foliata	*Linyphia phrygiana*
Araneus angulatus	*Mangora gibberosa*
Araneus arenatus	*Micrathena gracilis*
Araneus ectypus	*Micrathena sagittata*
Araneus marmoreus	*Misumenops asperatus*
Bathyphantes micraria	*Philodromus minutus*
Bathyphantes nigrinum	*Steatoda borealis*
Ceratinopsis interpres	*Tetragnatha laboriosa*
Euryopis funebris	*Theridion differens*
Eustala anastera	*Theridion frondeum*
Hyptiotes cavatus	*Theridion pennsylvanicum*
Icius hartii	*Theridula opulenta*
Leucauge venusta	*Tmarus* sp. (*caudatus?*)
Linyphia marginata	*Uloborus americana*
Linyphia conferta	

The Annual and Seasonal Succession.

The annual cycle of beech-maple spiders in their relation to the physical factors of the habitat, distribution in the forest and the dominants of the region is best understood in terms of its seasonal divisions, spring, summer, autumn and winter.

The Spring Period extends from about March 1 to June 1. The first portion is characterized by the absence of green vegetation and by rapidly rising temperature of both air and soil together with considerable rainfall. The forest as a habitat is still limited to the ground floor stratum. The spider community is practically restricted to this except such forms as on warmer days move about on the leaves and dead vegetation near the ground. The principal spiders present are Amaurobius bennetti, Gongylidiellum pallidum, Oedothorax probatus, Coelotes longitarsus, Phrurolithus palustris and Tmeticus aestivalis. The last three are the dominant species. It is interesting to note that all of the principal species are typical ground floor inhabitants.

The second portion is characterized by a well developed plant society of herb strata, advanced leaf condition of the

shrubs and appearance of green on the trees. Temperatures are much higher, rainfall less and insect life is abundant. The habitat now consists of two strata, ground floor and herb-shrub. The principal spiders of the ground floor are Amaurobius bennetti, Ariadne bicolor, Coelotes hybridus, Xysticus fraternus, Tmeticus aestivalis, Coelotes longitarsus, Phrurolithus palustris, Gongylidiellum pallidum and Hahnia agilis. The last four being the dominant forms. The principal species of Shrub-Herb Strata are Dendryphantes capitatus, Leucauge venusta, Ceratinopsis interpres and Theridion frondeum. The last two are the dominant forms.

The Summer Period extends from about June 1 to September 1. The first or aestival portion is characterized by rising temperature, increased evaporation and less light. The forest cover is well foliated and serves as shade. The dominant ground floor spiders are Agelena naevia, Phrurolithus alarius and Crustulina guttata. The principal species of the herb strata are Linyphia clathrata, Dendryphantes capitatus, Dictyna minuta, Leucauge venusta, Araneus marmoreus, Theridion frondeum and Micrathena sagittata. The last four are the dominant forms. Micrathena sagittata easily exceeds other forms being taken with almost every sweep of the net.

The later or serotinal period is characterized by a reversal of the aestival changes. The principal ground forms are Anyphaena saltabunda, Cicurina arcuata, Oedothorax probatus, Agelena naevia and Gongylidiellum pallidum. The last two are easily the dominant forms. Species of the Herb-Shrub stratum are Araneus marmoreus, Pisaurina mira, Leucauge venusta, Araneus arenatus and Mangora gibberosa. The last three are dominant forms, Mangora gibberosa far exceeding any other form. Numerous webs of Araneus arenatus with adult females are present. Micrathena sagittata so abundant in the late aestival is now limited to a small number of adults.

The Autmnal or Fall Period begins about September 1. This is characterized by a decline in temperature and some increase in light through reduction of shade from the forest cover. The forest floor is rapidly being covered anew with dead leaves which lie loosely upon the ground and are changing position frequently. This is rich in spiders from the herb and shrub strata as well as those that have migrated from the forest border. The herb-shrub stratum is still present but is rapidly

giving way to changing physical factors and assuming less importance. The principal species of the ground floor are Xysticus fraternus, Phrurolithus palustris, Amaurobius bennetti, Gongylidiellum pallidum, Oedothorax probatus and Anyphaena saltabunda. The last two are easily the dominant forms. The principal species of the early part of Autumn are Mangora gibberosa, Theridion frondeum, Dendryphantes capitatus, Pisaurina mira and Dictyna foliacea. The last two are dominants.

The Winter Period is characterized by the reduction of the habitat to a single stratum. Low temperature, increased light and more pronounced wind effects are present, a condition closely paralleling that of the tundra is now present. The principal ground floor forms are Anyphaena saltabunda, Linyphia clathrata, Phrurolithus palustris, Coras medicinalis, Amaurobius bennetti, and Xysticus fraternus. The last three are dominants. Physical factors now almost completely dominate biotic except for brief periods of rising temperature.

The Spider population of the beech-maple forest shows two distinct high peaks, one in late spring about May 1 and another in late summer about August 1. The late summer peak is not caused to an appreciable extent by the appearance of new species but is the result of the two distinct phases of spider life. In August the young from the spring adults have begun to appear and are at the peak within a few days. July is the worst month for collecting. Many of the adults of spring have disappeared, especially the males.

The dominant species of the Seasons follow:

Ground Floor Stratum	Herb-Shrub Stratum
SPRING.	
Prevernal period:	
Hahnia agilis	None
Gongylidiellum pallidum	
Phrurolithus palustris	
Coelotes longitarsus	
Vernal period:	
Hahnia agilis	*Ceratinopsis interpres*
Gongylidiellum pallidum	*Theridion frondeum*
Phrurolithis palustris	
Coelotes longitarsus	
SUMMER.	
Aestival period:	
Agelena naevia	*Micrathena sagittata*
Phrurolithus alarius	*Theridion frondeum*
Crustulina guttata	*Araneus marmoreus*
	Lecauge venusta

Serotinal period:

Agelena naevia	*Mangora gibberosa*
Gongylidiellum pallidum	*Araenus arenatus*
	Leucauge venusta

AUTUMN.

Anyphaena saltabunda	*Dictyna foliacea*
Oedothorax probatus	*Pisaurina mira*

WINTER.

Amaurobius bennetti	None
Phrurolithus alarius	
Xysticus fraternus	

Migration and Hibernation.

A few spiders hibernate in special situations, as, Herpyllus vasifer, under bark; Amaurobius bennetti, in logs and stumps; Dolomedes fontanus, in piles of wood and under bark of logs.

Most of the spiders, however, winter over in the leaves, humus and soil strata. The general migration begins about the middle of September and progresses according to temperature, frost conditions and duration of the herbage near the forest floor. By the middle of October the weeds and herbage are for the most part dead and few spiders are found on the same except near the ground.

Certain of the spiders migrate at once into the deeper strata and are not seen again until the emergence in the spring. Other species remain in the forest floor a considerable time and migrate downward just before freezing. Very warm periods call up from the deeper hibernation these forms not found during winter weather. Upon the resumption of cold they disappear returning to the region lower in the ground, probably below the frost line. Still other species remain comparatively near the surface in the top soil or leaf stratum. Among these are many young and adults that live throughout the winter as such, together with adults of species that die in the late fall; the egg sac containing the winter stage, either eggs or young as the case may be. These seem to consist of species that are able to tolerate freezing with very little harm.

The results of the experimental study of the physical factors and distribution of the total animal population in Elm-Maple forest (Weese 1924) shows little correlation between this winter distribution and the atmospheric humidity. Changes in the population of hibernating animals are more probably influenced by the changing temperature than by any other physical factor. Population apices apparently coincide with

temperature changes. These described temperature relations exist with reference to the distribution of spiders. Apparently however the upward and downward migration, though unrelated to atmospheric humidity is to a considerable extent dependent in addition to temperature upon the amount of water present in the forest floor. In both cold and warm dry weather many spiders are well down in the upper soil level. Following heavy rains these migrate upward into the less moist leaf layer. This migration is repeated several times during the winter occurring with each melting of the snow. During March and April this vertical shifting is quite in evidence during alternate freezing and thawing and wet and dry periods.

In the hibernation period biotic influences are at their lowest. Many of the spiders are in a quiescent or dormant condition except during the rising temperature periods referred to. In these periods there is little evidence of predatory activity on the part of spiders.

It has not been possible to determine with certainty the hibernation stage for all the species. Time has not permitted the collection of egg sacs and examination of these for young or the keeping of them until hatching for the determination of the species. The hibernation stage of many of the species rests upon the collection of spiders made in December, January and February. The finding of a single individual does not necessarily determine the nature of the winter stage. Such an occurrence may be accidental. The presence of three or more individuals, especially if found on different occasions is taken to be the hibernation stage. The over-wintering stage of all the species is considered. The determination of 73 of these has been made. The species are grouped under three headings, spiders that hibernate in the immature or adult form, those that winter over in the egg sac either as young or eggs, and species with the hibernation stage undetermined.

Spiders That Hibernate in Immature or Adult Form.

Amaurobinus bennetti
Anyphaena saltabunda
Araneus arabesca
Ariadne bicolor
Bathyphantes nigrinum
Bathyphantes zebra
Castaneria cingulata
Ceraticelus minutus
Ceratinopsis interpres
Cicurina brevis
Cicurina arcuata
Hahnia cinerea
Hahnia radula
Herpyllus vasifer
Hyptiotes cavatus
Lathys foxii
Lathys pallida
Linyphia clathrata
Linyphia phrygiana
Lycosa rabida
Maevia vittata
Microneta cornupalpis

Cicurina pallida
Clubiona obesa
Clubiona pallens
Coelotes hybridus
Coelotes longitarsus
Coelotes montanus
Coras medicinalis
Crustulina guttata
Dendryphantes capitatus
Dendryphantes (Phid.) audax
Dendryphantes (Phid.) clarus
Dictyna foliacea
Dictyna minuta
Dictyna sublata
Diplocephalus exiguus
Dolomedes fontanus
Ero furcatus
Euryopis funebris
Eustala anastera
Gongylidiellum pallidum
Habrocestum pulex
Hahnia agilis
Misumenops asperatus
Neon nellii
Nodocion sp.
Oedothorax probatus
Oedothorax montiferus
Oedothorax platyrhinus
Phrurolithus alarius
Phrurolithus palustris
Pisaurina mira
Schizocosa crassipes
Sergiolus variegatus
Steatoda borealis
Tetragnatha laboriosa
Theridion frondeum
Tmeticus aestivalis
Trachelas tranquillas
Trachelocamptus rostratus
Uloborus americana
Xysticus ferox
Xysticus fraternus
Zelotes ater

SPECIES THAT WINTER OVER IN THE EGG SAC AS EGGS OR VERY YOUNG.

Agelena naevia
Mangora gibberosa
Micrathena gracilis
Ordgarius bisaccatus
Amaurobius americana
Araneus arenatus
Leucauge venusta
Micrathena sagittata

HIBERNATION STAGE UNDETERMINED.

Allocosa funerea
Acacesia foliata
Araneus angulatus
Araneus ectypa
Araneus marmoreus
Anyphaena pectorosa
Bathyphantes micraria
Castaneria longipalpus
Ceratinella brunnea
Icius hartii
Linyphia conferta
Linyphia marginata
Lycosa gulosa
Misumenops gulosa
Oxyptila monroensis
Philodromus minutus
Pedanostethus pumulus
Phrurolithus similis
Pirata febriculosa
Prosopotheca minuta
Synemosyna formica
Theridion differens
Theridion pennsylvanicus
Theridula opulenta
Tmarus angulatus
Xysticus fraternus

SPECIFIC RELATION OF THE SPECIES TO THE ASSOCIATION.

The study of almost any vegetation association discloses the presence of numerous individuals of species that are not characteristic or typical of the association. In general the greater the diversity of conditions within the association and the smaller the area the larger will be the proportion of such forms present. Although the area under study was of considerable size and collections were made well within the forest and for the most part in rather densely populated portions the occurrence of such species of spiders was fairly common. This made necessary a careful study of all species present to determine

the forms typical of the habitat and those that belonged elsewhere. The spiders present have been placed in the following four groups, Forest spiders, Transitional, Field and Miscellaneous.

Under Forest spiders is included those species that are regularly found in beech-maple as evidenced by numerous collections in this and other forests. This does not imply that these species are not found in other types of forest. Incomplete collections I have made in Oak-Hickory forest yield 46 of the same species while Weese (1924) gives about 40 of the same as being present in Elm-Maple forest. If as Blake (1926) suggests the mere presence of the forest cover rather than the character of the same is the major factor in distribution we may expect to find a large proportion of the same spiders in other types of dedicuous forests and to considerable extent even in the coniferous forest.

In the Transition group are those spiders that are found regularly and in largest numbers in the forest border or in regions where the timber has been cut off resulting in a mixed grassland-forest association.

Field spiders are those species found regularly in open grassland, pastures, and other areas denuded of trees and shrubs.

Forms undetermined, on account of scarcity, those ranging about equally over all the other groups and those more typical of different deciduous forests are placed under the heading Miscellaneous.

The distribution makes no pretense at being wholly accurate but is that indicated by the study of the selected region, miscellaneous collections in the same vicinity, those in other beech-maple forests and numerous collections of Dr. W. M. Barrows.

In the case of a considerable number of species the grouping is correct. In some instances, however, the number of individuals collected is not sufficient to make certain of the correct habitat. This is especially true of such forms as Hahnia radula, Lathys sp. (pallida?), Phrurolithus similis, Dictyna sublata, Linyphia conferta and the forms in the miscellaneous group marked insufficient data.

This arrangement does not signify that a species is limited to a given association but it does mean that it is found habitually and in greatest numbers in the habitat indicated.

The comparative abundance of different species found in a habitat is no criterion for the placing of a species. A species typical for one habitat may exceed numerically in another a species typical for that habitat. This may quite well be seen in the case of Agelena naevia. This spider is far more abundant in fields than in woods and is typically a field spider. It exceeds numerically, however, many of the typical forest spiders. The same condition has been found to prevail for animals in general in the Elm-Maple forest (Weese). Animal sub-dominants during a considerable period of the year are species which have migrated from or are in course of migration to the forest edge or adjacent meadow.

The grouping though inaccurate in some instances is presented in the hope that it may stimulate intensive collection on the part of those ecologically minded with resultant verification or necessary corrections.

FOREST SPIDERS (Beech-Maple).

Araneus marmoreus
Ariadne bicolor
Amaurobius bennetti
Cicurina arcuata
Cicurina brevis
Cicurina pallida
Coelotes hybridus
Coelotes longitarsus
Coelotes montanus
Coras medicinalis
Hahnia radula
Dolomedes fontanus
Lathys foxii
Lathys sp. (*pallida?*)
Bathyphantes zebra
Linyphia clathrata
Microneta cornupalpis
Ceraticelus minutus
Clubiona obesa
Clubiona pallens
Anyphaena pectorosa
Anyphaena saltabunda
Phrurolithus alarius
Phrurolithus palustris
Phrurolithis similis
Gongylidiellum pallidum
Oedothorax probatus
Prosopotheca minuta
Tmeticus aestivalis
Ceratinopsis interpres
Trachelocamptus rostratus
Uloborus americana
Hyptiotes cavatus
Araneus angulatus
Araneus arenatus
Araneus ectypus
Leucauge venusta
Micrathena gracilis
Steatoda borealis
Nodocion sp.
Sergiolus variegatus
Zelotes ater
Philodromus minutus
Xysticus fraternus
Castaneria cingulata
Castaneria longipalpis
Habrocestum pulex
Neon nellii

TRANSITIONAL SPIDERS.

Pisaurina mira
Pirata febriculosa
Dictyna foliacea
Dictyna minuta
Dictyna sublata
Ordgarius bisaccatus
Micrathena sagittata
Misumenops asperatus
Misumenops oblongus
Dendryphantes capitatus
Icius hartii
Xysticus nervosus
Theridion differens
Theridula opulenta
Linyphia conferta
Linyphia marginata
Linyphia phrygiana
Acacesia foliata
Synemosyna formica
Maevia vittata
Dendryphantes (*Phid.*) *clarus*

FIELD SPIDERS.

Agelena naevia	*Mangora gibberosa*
Tetragnatha laboriosa	*Allocosa funerea*
Crustulina guttata	*Xysticus ferox*
Theridion frondeum	*Araneus arabesca*
Trachelas tranquillus	*Bathyphantes nigrinus*

MISCELLANEOUS.

Amaurobius americana, forest, but more typically Oak-Hickory.
Hahnia agilis, field and forest; probably also transitional.
Herpyllus vasifer, woods under bark, chiefly Oak-Hickory.
Lycosa rabida, insufficient data.
Pedanostethus pumulus, insufficient data.
Bathyphantes micraria, insufficient data.
Ceratinella brunnea, insufficient data.
Oedothorax montiferus, insufficient data.
Diplocephalus exiguus, insufficient data.
Ero furcatus, insufficient data.
Theridion pennsylvanicus, insufficient data.
Lycosa gulosa, insufficient data.
Oxyptila monroensis, insufficient data.
Eustala anastera, insufficient data.
Tmarus angulatus, insufficient data.
Oedothorax platyrhinus, insufficient data.
Schizocosa crassipes, all habitats.
Dendryphantes (Phid.) audax, all habitats.

COMPARATIVE ABUNDANCE OF THE SPECIES.

Observations and collections were carried on in the selected environment over a period of approximately sixteen months. Numerous collections were made of a general nature during this period. It was quite apparent from general observation that certain species were much more abundant than others. With a view to determining the relative abundance of the species quantitative collecting was done in the selected region. These collections were made from April 13, 1928 to April 10, 1929 approximately every two weeks except during the winter months when conditions were constant for a longer period. All individuals of such collections were saved, siftings being gone over carefully within a few hours after collection. Every effort was made to equalize the time and attention given to different situations and species in order that the true conditions might best be represented. One of the most difficult and time consuming features in connection with this was the identification of the young spiders. These were carefully sorted and kept, sometimes for several weeks until an adult was found and identified after which successive growth stages were carefully compared and the species determined.

Some of all the species found were present in the Special Collections. The species present and the total number of each were as follows:

INDIVIDUALS AND SPECIES PRESENT IN THE SPECIAL COLLECTIONS.

Ariadne bicolor	56
Amaurobius americana	16
Amaurobius bennetti	158
Agelena naevia	106
Cicurina arcuata	143
Cicurina brevis	7
Cicurina pallida	22
Coelotes hybridus	53
Coelotes longitarsus	146
Coelotes montanus	6
Coras medicinalis	32
Hahnia agilis	154
Hahnia cinerea	23
Hahnia radula	9
Pisaurina mira	82
Dolomedes fontanus	53
Allocosa funera	6
Lycosa gulosa	4
Lycosa rabida	7
Schizocosa crassipes	18
Pirata febriculosa	2
Oxyptilus monroensis	3
Dictyna foliacea	84
Dictyna minuta	16
Dictyna sublata	16
Lathys foxii	18
Lathys sp. (pallida?)	4
Pedanostethus pumulus	3
Crustulina guttata	18
Steatoda borealis	6
Euryopis funebris	7
Theridion differens	2
Theridion frondeum	264
Theridion pennsylvanicum	6
Theridula opulenta	3
Bathyphantes micraria	2
Bathyphantes nigrinus	4
Bathyphantes zebra	21
Linyphia clathrata	50
Linyphia conferta	2
Linyphia marginata	5
Linyphia phrygiana	16
Microneta cornupalpis	11
Ceraticelus minutua	4
Ceratinalla brunnea	5
Gongylidiellum pallidum	244
Oedothorax montiferus	3
Oedothorax platyrhinus	4
Oedothorax probatus	196
Prosopotheca minuta	8
Tmeticus aestivalis	209
Ceratinopsis interpres	69
Diplocephalus exiguus	26
Trachelocamptus rostratus	14
Uloborus americana	18
Hyptiotes cavatus	8
Acacesia foliata	6
Araneus angulatus	4
Araneus arabesca	27
Araneus arenatus	42
Araneus ectypus	4
Araneus marmoreus	71
Eustala anastera	4
Mangora gibberosa	134
Ordgarius bisaccatus	1
Leucauge venusta	109
Tetragnatha laboriosa	5
Micrathena gracilis	11
Micrathena sagittata	154
Ero furcatus	8
Herpyllus vasifer	3
Nodocion sp.	9
Sergiolus variegatus	2
Zelotes ater	8
Philodromus minutus	3
Misumenops asperatus	56
Misumenops oblongus	5
Tmarus sp. (angulatus?)	4
Xysticus ferox	10
Xysticus fraternis	184
Xysticus nervosus	7
Clubiona obesa	39
Clubiona pallens	19
Anyphaena pectorosa	16
Anyphaena saltabunda	101
Phrurolithus alarius	110
Phrurolithus palustris	260
Phrurolithus similis	7
Trachelas tranquillus	4
Castaneria cingulata	16
Castaneria longipalpus	2
Synemosyna formica	1
Maevia vittata	27
Habrocestum pulex	25
Dendryphantes (Phid.) audax	10
Dendryphantes capitatus	167
Dendryphantes (Phid.) clarus	15
Icius hartii	6
Neon nellii	31
Total	4201

Examination of the list as to representation of the species in the total population makes apparent the fact that a com-

paratively small number of species make up the greater proportion of individuals present. The principal species and their numerical relation to the total number of spiders present are here given.

SPECIES REPRESENTED BY 100 OR MORE INDIVIDUALS.

Amaurobius bennetti	*Mangora gibberosa*
Agelena naevia	*Leucauge venusta*
Cicurina arcuata	*Micrathena sagittata*
Coelotes longitarsus	*Xysticus fraternus*
Hahnia agilis	*Anyphaena saltabunda*
Theridion frondeum	*Phrurolithus alarius*
Congylidiellum pallidum	*Phrurolithus palustris*
Oedothorax probatus	*Dendryphantes capitatus*
Tmeticus aestivalis	

The above 17 species, or 17.1% of the total number of species, constitute 67.6% of the total number of individuals in the special collections.

SPECIES REPRESENTED BY 50 OR MORE INDIVIDUALS.

Ariadne bicolor	*Linyphia clathrata*
Coloetes hybridus	*Ceratinopsis imterpres*
Pisaurina mira	*Araneus marmoreus*
Dolomedes fontanus	*Misumenops asperatus*
Dictyna foliacea	

The above total of 26 species, or 26.2% of the entire number of species, equals 81.2% of all individuals in the special collections.

SPECIES REPRESENTED BY 25 OR MORE INDIVIDUALS.

Coras medicinalis	*Clubiona obesa*
Diplocephalus exiguus	*Maevia vittata*
Araneus arabesca	*Habrocestum pulex*
Araneus arenatus	*Neon nelli*

The above 34 species, or slightly more than a third (34.2%) of all species, aggregate 3,664 individuals or 87.2% of the total 4,201 individuals in the eighteen special collections from April 13, 1929, to April 10, 1928, inclusive.

SUMMARY AND CONCLUSIONS.

Ninety-nine species of spiders were present in the forest studied, thirty-four of which constitute 87.2% of the total number of individuals.

Numerically dominant species of spiders present in the Beech-Maple forest are not always typical forest spiders but may be forest edge, transitional or even field forms which migrate into the forest.

There is in the Beech-Maple forest a stratification of spider population which correlates with that of the physical factors and the vegetation.

Of the spiders whose specificity for the association was determined 49 were typical beech-maple 21 transitional and 9 typical field forms.

Hibernation of spiders is preceded by a downward migration of the spider population apparently resulting from the changing physical factors, temperature probably being the most important of them. Physical factors in winter become dominant, biotic negligible.

The majority of the spiders winter over as immature or adult forms, this being true of 65 of the 73 species whose over-wintering stage was determined.

A Seasonal succession of societies was shown by the spiders of the forest studied, these being represented by a few principal species two or three of which were easily numerical dominants.

The Spider population of Beech-Maple forest exhibits two high peaks, late spring and early fall. The high peak of autumn is not due to the presence of new species but to the appearance of young of the species which matured in late spring.

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THE ALGAL FOOD OF PIMEPHALES PROMELAS.
(Fathead Minnow)*†

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INTRODUCTION.

In recent years increasing interest has been shown by icthyologists and those people concerned with fish culture regarding the food of our common fishes. The interest at the present time is centered in the study of the food of the possible species which may be used as forage fish for bass or other carnivorous pond fishes. *Pimephales promelas*, Rafinesque, the fathead minnow, is a species under such consideration. The purpose of this paper is to describe the food of the fathead with special emphasis on the algal food, but also with mention of such animal forms and other materials found in the alimentary canal. This work has been carried on for over a year at the Botany Department of the Ohio State University and at the Franz Theodore Stone Laboratory at Put-in-Bay, Ohio.

The writer wishes to express her gratitude to those people who so kindly aided in the preparation of this paper: to Dr. L. H. Tiffany, of Ohio State University, for suggesting and directing the problem; to Mr. E. L. Wickliff, of the Ohio State Division of Fish and Game, for furnishing material for study; to Mr. Milton Trautman, for collecting some of the materials used; and to Dr. R. V. Bangham, of the College of Wooster, for helpful suggestions and for interest shown during the progress of the work.

METHODS OF COLLECTION AND STUDY.

The minnows were collected by means of a fine-meshed seine. They were placed immediately in a ten per cent formalin solution to preserve the contents of the stomach and intestine. Later a longitudinal slit was made in the ventral body wall and the alimentary canal was removed. Each alimentary

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canal was placed in a small shell vial filled with 6-3-1 preservative (6 parts water, 3 parts 95% alcohol, and 1 part formalin). When a detailed study was made of the contents of the alimentary canal small bits were removed and microscopic slides were prepared. Permanent glycerin mounts for future reference were made of the stomachic or intestinal contents of each fish observed. The slides were studied first under the medium and then the high powers of the compound microscope with the occasional use of the oil immersion. The content of many of the alimentary canals was spread out in flat dishes and was studied under the low power of the compound microscope.

Two hundred three fish were studied. The size ranged from 6 centimeters long, which is practically the maximum length of the fathead, to 2.7 centimeters. The measurements were taken from the point of the snout to the base of the caudal fin.

FEEDING HABITS.

Up to the present time there has been little work done on the feeding habits of *Pimephales promelas*. According to Forbes and Richardson (5): ". . . . . it belongs to the mud-eating group of minnows, and its alimentary structures correspond to this fact, the intestine being two to three times the length of the head and body, and the pharygeal teeth not hooked but with well developed grinding surface. Our only knowledge of its food is derived from a study of four specimens from muddy streams in northern and central Illinois. The intestines of these were largely filled with mud containing some algæ and a considerable number of insects, partly of terrestrial species and partly aquatic larvæ of Diptera."

Lord (13) in the discussion following his paper (p. 96) on *The Blackhead Minnow As a Forage Fish* given at the Meetings of the American Fisheries Society at Hartford, Connecticut, in August, 1927, says: ". . . . . the blackhead (= fathead) minnow, after it reaches a certain size, say forty millimeters, can be seen browsing along on the stems of aquatic plants, scraping off the diatom slime and small algæ. It is not a carnivorous fish so far as can be seen."

A study of the alimentary canals of *Pimephales promelas* certainly shows that it belongs to the mud-eating group of minnows. In practically every one of the fish studied which were taken from the streams or small rivers the alimentary

canals were filled, sometimes even gorged, with sand and silt. Mixed in with the silt were found the plant and animal remains. This would tend to indicate that the fathead also feeds near the bottom, taking in mud, plant and animal food, and organic remains. Specimens taken from regions along Lake Erie show a decided decrease in the amount of mud present, (in some cases it was entirely absent), but by far the greater number of fatheads is found in the muddy creeks or in small sluggish rivers; so it seems they can be considered as belonging to the mud-eating group. Judging from the predominance of fragments of Oscillatoria in the stomachic and intestinal contents, it would seem that the minnow nibbles, to a certain extent at least, on that filamentous blue-green. Broken filaments of Oedogonium and Spirogyra were observed frequently while it was not at all uncommon to find short or even quite long filaments of other filamentous greens. Whether these were nibbled directly from the plant mass or whether they entered the fish by accident as water was taken into the mouth during respiration cannot be said. The filamentous greens were found to be very much more abundant and the filaments themselves were much longer than were those observed by Tiffany (20) in his work on the algal food of the young gizzard shad.

ORGANISMS COMPRISING THE FOOD.

Only a few statements have been made by investigators concerning the food of the fathead. Reference has been made in the preceding paragraph to the report of Forbes and Richardson (5) on the food of *Pimephales promelas*.

Forbes (6) in another paper says: ". . . . about three-fourths of the intestine consisted of mud, the remainder being wholly insects. These were partly terrestrial species, occurring accidentally in the water, and partly aquatic larvæ of Diptera. The vegetable food of these specimens amounted to about one per cent, chiefly various unicellular Algæ."

Pearse (15) in giving a quantitative summary of the food of three specimens in per cent says, "Tanytarus gregarious larvæ, 79.3; mites, 1.6; amphipods, 0.3; Cyclops, 2.6; oligochaetes, 6; diatoms and other algæ, 1.3; and debris, 8.3."

Lord (13) found that "after a size of 25 to 30 mms. was reached the fish were observed feeding on algæ to a great extent. It is thus non-competitive with game-fish."

It seems that the habitat in which the fish are taken determines to a great extent what will be found in the alimentary canal. The fish which were investigated came, for the most part, from streams in southwestern Ohio. One lot of minnows was collected June 24, 1928, in White Oak Creek, Brown County, and also in the East Fork of the Miami River, Clermont County, when the waters were high and the streams were full of mud. These fish were found to be filled with mud or silt and plant and animal food proved to be rather scarce. The algal forms consisted almost entirely of Closteriums, Diatoms, and various species of Euglena along with filaments of Rhizoclonium and disintegrated Spirogyra. The Entomostraca were proportionately much more scarce than were the fragments of leaf tissue, tracheæ, and epidermal hairs which were found mixed in with the mud. In fact many of the fish showed practically no indication of having taken in animal food.

On the other hand a few fish were collected in Maumee Bay, at the mouth of the Maumee River, and also at the mouth of the Portage River which showed a varied diet of many small algal forms and Entomostraca. These fish were practically devoid of mud.

The remainder of the fish, taken from various streams of the Ohio River drainage system, showed a very large percentage of mud, but they also showed a larger percentage of algal species as well as a slightly larger percentage of animal forms.

Of the animal forms observed, the Entomostraca were by far the most abundant. The Cladocera were found most frequently with the Copepoda being second in importance. The Ostracoda were found to be much less abundant than were the other two orders. Other animal forms that were observed were Rotifers, Nematoda, and the remains of a few small insects. Setæ of the freshwater Oligochaeta and masses of pigment cells were frequently found. Very often the only evidence of animal food was an occasional appendage or perhaps a furcal ramus of a copepod.

Pimephales promelas is considered by some to be more of an animal than a plant feeder, but present observations do not indicate that such is the case. Further it does not appear to be nearly so much of an animal feeder as Kraatz (11) has shown *Pimephales notatus* to be.

The algal material found in the alimentary canal is probably the only plant material which is used for food to any great

extent. The blue-greens are very abundant as compared with the number found by Tiffany (20) in the gizzard shad. The different type of habitat of the fathead probably accounts for this increase. The number of species of the Protococales, (Chlorococcales) is much smaller, while the species lists of Desmids, Euglenoidia, and filamentous greens are much longer than those reported by Tiffany (20). Not only can differences in the habitats account for the variations in the algal forms found in the alimentary canals of the two fish, but also the types of gill rakers present in the fish can offer some explanation for these variations. The gill rakers of *Pimephales promelas* are much shorter and are much fewer in number than are those of the gizzard shad. This fact alone can probably account for the scarcity in the numbers of the Protococcales reported for the fathead.

ALGAL FOOD.

Table I shows the 128 species and varieties of algæ which were identified in the alimentary canals of the 203 fatheads investigated. The table is arranged to show the relative abundance of the species according to two general habitats: (a) bays and the mouths of several rivers in the western end of Lake Erie (indicated by "Erie"), and (b) streams and small rivers of the Ohio River drainage system (indicated by "O. R. D."). "R" in the table refers to rare or occasional, "C" to common, and "A" to abundant. When the letter x is found in two columns under the same general habitat, for a single species, it means that the abundance of the species is one or the other depending upon the locality in which the fish were collected.

TABLE I.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Myxophyceæ.						
Aphanocapsa pulchra (Kuetz) Raben	x				x	
Chroococcus limneticus Lemm	x					
" " var. *distans* G. M. Smith	x					
" *turgidus* (Kuetz) Naeg				x		
" *varius* A. Braun				x		
Coelosphaerium kuetzingianum Naeg		x		x		
" *naegelianum* Unger	x			x		
Gloeocapsa dubia Wartmann	x					
" *gelatinosa* Kuetz	x					

TABLE I—Continued.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Gomphosphaeria lacustris Chodat	x			x		
Merismopedia elegans A. Braun				x		
" *glauca* (Ehr) Naeg		x	x			x
" *punctata* Meyen		x		x		
" *tenuissima* Lemm		x		x		
Microcystis aeruginosa Kuetz	x			x		
" *flos-aqua* (Witt) Kirch		x		x		
" *incerta* Lemm	x	x				
" *pulvera* (Wood) Migula	x					
Lyngbya aestuarii (Mert) Lieb				x		
" *birgei* Smith				x		
" ? *cryptovaginata* Schkorb				x		
" *kuetzingiana* Kirch				x		
" ? *lutea* (Ag.) Gomont				x		
Oscillatoria amoena (Kuetz) Gomont				x		
" *brevis* Kuetz				x		
" *laetevirens* (Crouan) Gomont					x	
" *limosa* Agardh	x					x
" *princeps* Vauch				x	x	
" *sancta* Kuetz				x		
" *tenuis* Agardh		x				x
Phormidium ? *molle* (Kuetz) Gomont	x					
Anabaena lemmermanni P. Richter	x	x				
Anabaena spp?	x			x		
Nodularia paludosa Wolle				x		
Gleotrichia natans (Hedw.) Rab				x		
Chlorophyceæ.						
Eudorina elegans Ehr	x					
Sphaerocystis schroeteri Chodat				x		
Pediastrum boryanum (Turpin) Menegh		x		x		
" *clathratum* (Schroeter) Lemm. var. *microporum* Lemm				x		
" *duplex* Meyen	x					
Pediastrum duplex Meyan var. *clathratum* A. Braun	x					
" *simplex* (Meyen) Lemm						x
Dictyosphaerium ehrenbergianum Naeg	x					
" *puchellum* Wood	x					
Westella botryoides (W. West) de Wildeman	x					
Ankristrodesmus falcatus (Corda) Ralfs	x			x		
" *setigerus* forma *minor* (Schroder) G. S. West				x		
Schroederia judayi G. M. Smith	x					
Coelastrum microporum Naeg	x					
Kirchneriella obesa (W. West) Schmidle	x	x				
Oocystis borgei Snow	x	x				
" *elliptica* W. West forma *minor* W. West				x		
Actinastrum gracillimum G. M. Smith	x					
Scenedesmus abundans (Kirch) Chodat	x					
" *bijuga* (Turpin) Lager		x			x	
" *denticulatus* Lager	x					
" *dimorphus* (Turpin) Kuetz		x		x		
" *obliquus* (Turpin) Kuetz	x			x		
" *opoliensis* P. Richter	x				x	
" *quadricauda* (Turpin) de Bréb			x			x
" " var. *parvus* G. M. Smith	x			x		

TABLE I—Continued.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Scenedesmus quadricauda var. *quadrispina* (Chodat) G. M. Smith	x	....	....	x	....	....
Tetraedron minimum (A. Braun) Hansg	x	....	....	....	....	....
" *tropicum* W. & G. S. West	....	....	....	x	....	....
Stigeoclonium tenue (Ag.) Kuetz	....	....	....	x	....	....
Geminella minor (Naeg) Heer	....	....	....	x	x	....
Ulothrix tenerrima Kuetz	x	....	....	....	....	....
Cladophora crispata (Roth) Kuetz	....	....	....	x	....	....
" *glomerata* (L.) Kuetz	....	....	....	x	x	....
Rhizoclonium hieroglyphicum (Ag.) Kuetz	....	....	....	....	x	....
Bulbochaete spp?	....	....	....	x	....	....
Oedogonium exospirale Tiffany	....	....	....	x	....	....
Oedogonium spp?	x	....	....	....	x	....
Spirogyra spp?	....	....	....	....	....	x
Closterium acerosum (Schrank) Ehr	x	....	....	....	....	x
" " (Schrank) Ehr. var. *elongatum* Bréb	....	....	....	x	x	....
" " (Shrank) Ehr. var. *minus* Hantz	....	....	....	x	....	....
" *lanceolatum* Kuetz	x	....	....	....	x	....
" *lunula* (Mull) Nitz. var. *intermedium* Gutw	....	....	....	x	....	....
" *moniliferum* (Bory) Ehr	x	....	....	x	....	....
" *peracerosum* Gay var. *elegans* G. S. West	....	....	....	x	....	....
" *leibleinii* Kuetz	....	....	....	x	....	....
Closterium pronum Bréb	....	....	....	x	....	....
" *ulna* Focke	....	....	....	x	....	....
Cosmarium adoxum West & G. S. West	....	....	....	x	....	....
" *angulossum* Bréb	....	....	....	x	....	....
" *bireme* Nordst	....	....	....	x	....	....
" *cytomatoplerum* Nordst	....	....	....	x	....	....
" *didymochondrum* Nordst	x	....	....	....	....	....
" *garrolense* Roy & Biss	x	....	....	x	....	....
" *laeve* Rab	....	x	....	x	....	....
" *logiense* Bis	x	....	....	....	....	....
" *obtusatum* Schmidle	....	....	....	x	....	....
" *pyramidatum* Bréb	....	....	....	x	....	....
" *reniforme* (Ralfs) Arch	....	....	....	x	....	....
" *speciosum* Lund. var. *simplex* Nordst	x	....	....	x	x	....
" *undulatum* Corda var. minutum Tittr	x	x	....	....	....	....
Hyalotheca dissiliens (Smith) Bréb	....	....	....	x	....	....
Penium margaritaceum (Ehr) Bréb	....	....	....	x	....	....
Pleurotaenium ehrenbergii (Bréb) De Bary	....	....	....	x	....	....
Staurastrum paradoxum Meyen	x	....	....	x	....	....
Heterokonteæ.						
Tribonema bombycinum Agardh	x	....	....	....	....	....
Euglenineæ.						
Euglena acus Ehr	....	....	....	....	x	x
Euglena fusca (Klebs). Lemm	....	....	....	x	....	....
" *pisciformis* Klebs	....	....	....	x	....	....
" *spirogyra* Ehr	x	....	....	....	....	....
" " Ehr. var. *laticlavius* (Huber) Lemm	....	....	....	x	....	....
" " Ehr. var. *marchia* Lemm	....	....	....	x	....	....
" *spiroides* Lemm	x	....	....	....	x	....

TABLE I—Continued.

Algal Species or Variety	Erie			O. R. D.		
	R	C	A	R	C	A
Phacus longicauda (Ehr.) Duj				x		
" *pleuronectes* (O. T. M.) Duj				x		
" *triqueter* Ehr				x		
Peridinieæ.						
Peridinium aciculiferum Lemm				x		
" *inconspicuum* Lemm				x		
Diatomeæ (Bacillarieæ).						
Melosira distans (Ehr) Kuetz		x				
" *varians* Agardh	x			x		
Coscinodiscus lacustris Grunow		x				
Tabellaria fenestra (Lyng) Kuetz		x		x		
Meridion circulare Agardh				x		
Synedra spp?		x			x	
Cocconeis placentula Ehr		x			x	
Cocconeis spp?						x
Rhoicosphenia curvata (Kuetz) Grunow				x		
Navicula spp?			x			x
Pinnularia divergens W. Smith				x		
Pinnularia spp?		x			x	
Gyrosigma kuetzingii Grunow	x					x
" *scalproides* Rab	x				x	
" *spenceri* W. Smith				x		
Gomphonema acuminatum Ehr				x		
Amphora ovalis Kuetz					x	
Epithemia argus Ehr				x		
Nitzschia sigmoides (Nitz) W. Smith				x		
" *vermicularis* (Kuetz) Hantz				x	x	
Cymatopleura solea Bréb	x					x
Surirella biseriata (Ehr) Bréb				x		

SUMMARY OF THE DISTRIBUTION OF SPECIES AMONG THE ALGAL GROUPS.

Table II is a summary of all the algal forms found, giving numbers of the genera, families, orders, and divisions.

TABLE II.

MYXOPHYCEÆ, 34.	
CHROOCOCCALES	18
Chroococcaceæ	18
Aphanocapsa	1
Chroococcus	4
Coelosphaerium	2
Gloeocapsa	2
Gomphosphaeria	1
Merismopedia	4
Microcystis	4
HORMOGONEALES	16
Oscillatoriaceæ	13
Lyngyba	5
Oscillatoria	7
Phormidium	1
Nostocaceæ	2
Anabaena	1
Nodularia	1
Rivulariaceæ	1
Rivularia	1
CHLOROPHYCEÆ, 63.	
Isokontæ, 35.	
VOLVOCALES	2
Volvocaceæ	1
Eudorina	1
Palmellaceæ	1
Sphaerocystis	1
PROTOCOCCALES	27
Hydrodictyaceæ	5
Pediastrum	5
Dictyosphaeriaceæ	3
Dictyosphaerium	2
Westella	1
Autosporaceæ	19
Ankistrodesmus	2
Schroederia	1
Coelastrum	1
Kirchneriella	1
Oocystis	2
Actinastrum	1
Scenedesmus	9
Tetraedron	2
CHAETOPHORALES	1
Chaetophoraceæ	1
Stigeoclonium	1
ULOTRICHALES	2
Ulotrichaceæ	2
Geminella	1
Ulothrix	1
SIPHONOCLADIALES	3
Cladophoraceæ	3
Cladophora	2
Rhizoclonium	1
Stephanokontæ, 1.	
OEDOGONIALES	1
Oedogoniaceæ	1
Bulbochaete	
Oedogonium	1
Akontæ, 27.	
ZYGNEMALES	
Zygnemaceæ	
Spirogyra	
Desmidiaceæ	27
Closterium	10
Cosmarium	13
Hyalatheca	1
Penium	1
Pleurotaenium	1
Staurastrum	1
HETEROKONTEÆ, 1.	
HETEROTRICHALES	1
Tribonemaceæ	1
Tribonema	1
EUGLENINEÆ, 10.	
Euglenaceæ	10
Euglena	7
Phacus	3
PERIDINIEÆ, 2.	
Peridiniaceæ	2
Peridinium	2
DIATOMEÆ (BACILLARIEÆ), 18.	
CENTRICÆ	3
Melosiraceæ	2
Melosira	2
Coscinodiscaceæ	1
Coscinodiscus	1
PENNATÆ	15
Tabellariaceæ	1
Tabellaria	1
Meridionaceæ	1
Meridion	1
Fragilariaceæ	
Synedra	
Achnanthaceæ	2
Cocconeis	1
Rhoicosphenia	1
Naviculaceæ	4
Navicula	
Pinnularia	1
Gyrosigma	3
Gomphonemaceæ	1
Gomphonema	1
Cymbellaceæ	2
Amphora	1
Epithemia	1
Nitzschioideæ	2
Nitzschia	2
Surirellaceæ	2
Cymatopleura	1
Surirella	1
TOTAL NUMBER OF FORMS RECORDED	128

NOTES ON SOME ALGAL FORMS.

Pediastrum simplex (Meyen) Lemm.

This species was found to be by far the most abundant of all the species of Pediastrum. It can be recognized easily by the single process of the marginal cells of the coenobium and by the compact plate. The species as observed was found to be quite variable both as to the size of the coenobium and as to the length of the marginal process.

Cosmarium cymatopleurum Nordst.

Several specimens were observed each having the following dimensions: length 58μ; breadth 46μ; isthmus 15μ. West (24) gives for the dimensions of the species length 82–97μ; breadth 60–70μ; isthmus 25–30μ. The specimens observed fit the descriptions and diagram in West (24) except for the much smaller dimensions.

Cosmarium undulatum Corda var. **minutum** Wittr.

The specimens observed had the following dimensions; length 27μ; breadth 27μ; isthmus 6μ; while West (24) records the dimensions as being length 21–28μ; breadth 18–21μ; isthmus 8.5–10μ.

Cosmarium logiense Bissett.

The dimensions of the few specimens found were length 42μ; breadth 30.8μ; isthmus 11.5μ, while West's (24) dimensions are length 61–65μ; breadth 48–50μ; isthmus 16–18μ. The granules in the wall were too small and were entirely too numerous to consider the specimens as a variety of *Cosmarium reniforme* (Ralfs) Arch. They seemed to be closest to *Cosmarium logiense.*

Closterium pronum Bréb.

A single specimen was found and this seemed to be nearer to *Closterium pronum* than any of the related species, although it was somewhat larger. The species observed was 500μ in length, 11μ in breadth, with the apices measuring 3.65μ. *Closterium pronum* is recorded in West (24) as having a length of 313–423μ and a breadth of 5.7–9μ. This together with the variations noted under *Cosmarium pronum* is perhaps a distinct variety, but since only a single plant was observed, the complete diagnosis awaits further data.

Euglena spiroides Lemm.

Of the fairly large number of specimens observed several were noted which may be a larger variety of the species. *Euglena spiroides* (14) (23) is recorded as being 60–170μ long and 16μ in diameter, while these few specimens were from 219–269μ in length and were 23.4μ in diameter.

Oedogonium exospirale Tiffany.

This species was identified by a single isolated oospore. The oospore of *Oedogonium exospirale* can be recognized easily by the spiral ribs of the outer wall which unite at the poles of the spore.

Although filaments of Oedogonium were found many times, none of them contained fruiting cells so they could not be identified. Filaments showing the basal holdfast were noticed occasionally.

Bulbochaete spp.?

Bulbochaete occurred several times in the fish collected from southwestern Ohio, but the alga was never found in the fruiting condition.

Spirogyra spp?

Disintegrated Spirogyra was found many times, but the filaments were never seen conjugating. The lengths of the filaments varied considerably, some being but several cells in length, while others were very long.

Oscillatoria spp.?

The species list for Oscillatoria is shorter than it should be because fragmentation made absolute identification of the end cell extremely difficult. *Oscillatoria tenuis* was by far the most abundant of any of the algal species recorded.

Lyngbya ? cryptovaginata Schkorb.
Lyngbya ? lutea (Ag.) Gomont.

These species fit the descriptions in Pascher (8) except for the habitats.

The Lyngbyas as a whole were difficult to identify because of the fragmentation and isolation of the filaments. The species list is perhaps much longer than shown in Table I.

Phormidium ? molle (Kuetz) Gomont.

The species could not be identified absolutely from the single filament observed.

Diatoms.

The diatoms were extremely abundant, but only a few were identified. The genus Navicula, as would be expected, was the most common genus represented.

SUMMARY.

1. *Pimephales promelas* may well be considered as belonging to the mud-eating group of minnows. It is a bottom-feeder, taking in plant and animal food and organic remains along with large quantities of mud.

2. Although previous records tend to indicate that the fathead takes in more animal than plant food, present observations show that animal food is proportionately less abundant than is the plant food.

3. Two hundred three fish were examined and a total number of one hundred twenty-eight species and varieties of algæ were identified.

4. The 128 species and varieties are distributed among the classes of algæ as follows: Myxophyceæ 34, Chlorophyceæ 63, Heterokonteæ 1, Euglenineæ 10, Peridineæ 2, Diatomeæ 18.

5. The algal species found in the alimentary canal of the fathead depend upon the habitat in which the fish is taken; yet the number and size of the gill rakers of the fish determine to a great extent what forms are retained in the alimentary canal.

6. Since *Pimephales promelas* takes in but a small amount of animal food, it is not much in competition with the carnivorous fish. If the fatheads can be obtained in large enough numbers, therefore, they should be found desirable as a forage fish.

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THE MAJOR AND MINOR SULCI OF THE BRAIN OF THE SHEEP.

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INTRODUCTION.

A description of the constant and variable sulci of the cerebral hemispheres of the sheep brain is presented as a preliminary to the description of the cytoarchitecture. Owing to the lack of definite knowledge of the limits of cytoarchitectural zones the nomenclature of Krueg ('78) is followed. The same lack of knowledge makes it unsafe in many cases to name gyri and these have been omitted since a sulcus may lie on the border of a cell zone or within the zone. Krueg's excellent description covers a large series of ungulates indicating major, minor, and transient sulci as well as the order of appearance in embryonic stages along with a comparison with carnivores.

Krueg's paper does not include a large series of any one type and a description of a larger series of the sheep brain is needed in order to refer the description of the cytoarchitecture of a particular brain to the type or variations of the type. Fifty brains have been examined giving one hundred cases since the ordinary variations are as frequent on two hemispheres of the same brain as on the hemispheres of two different brains. For details of the insular area the papers and bibliographies of Clark ('96) and Holl ('00) should be consulted. The nomenclature of fissures, however, follows that of Krueg rather than that of Holl.

THE DORSAL SURFACE.

(Fig 1)

The dorsal surface, aside from the f. longitudinalis, presents one tranverse fissure, the Sylvian, one transverse sulcus, ansatus (cruciatus), and five longitudinal sulci, coronalis, lateralis, entolateralis, ectolateralis and suprasylvius and one diagonal sulcus, the diagonal. The ansate and coronal sulci are described in detail under the rostral surface.

Of the four longitudinal sulci on the caudal surface of the hemisphere, two, the lateral (Fig. 1, L) and the suprasylvian (Figs. 1, S. S. A, S. S. M., S. S. P.), are constant as to their depth but somewhat variable as to their position. The s. entolateralis (Fig. 1, Enl.) (medialis Burkholder '04) and s. ectolateralis (Fig. 1, Ecl.) (lateralis Burkholder '04) are shallow and vary both in length and position. A good deal of variation exists in the names of sulci associated with s. lateralis. The name of s. lateralis follows the description of Krueg ('78) and the suggestion of Kappers ('21, p. 1152) that the s. lateralis is the deepest sulcus on the caudal portion of the dorsal surface.

The s. entolateralis (Fig. 1, Enl.) is shallow and quite variable in length but never entirely absent although it may be represented by detached depressions. When best developed it lies next to the f. longitudinalis parallel to s. lateralis. Its rostral end may join the s. lateralis or turn medially and end on the medial border of the hemisphere. Its caudal end usually extends to and sometimes completely around the caudal border of the hemisphere where it may bifurcate over the dorsal end of ramus horizontalis posterior. When not present as a continuous sulcus, the slight depressions occupying its position are too variable to describe.

The s. lateralis (Fig. 1, L.) (intermedius, Burkholder '04) is not more pronounced on superficial examination than entolateral and ectolateral but if it is examined in transverse sections or if it is opened it is found to be a deep sulcus with convoluted walls throughout the caudal two-thirds of its length while the lateral wall of the sulcus forms a well defined operculum over the medial wall. It penetrates the brain wall in a ventrolateral direction.

The s. lateralis is fairly constant in its position with reference to the f. longitudinalis, i. e., in its distance from the median border of the hemisphere and in the fact that its caudal end extends except in rare cases (one in one hundred) around the caudal border of the hemisphere where it may join or be continued as the r. occipitotemporalis (Fig. 3, Oct.). In the case mentioned the caudal end of lateralis is separated from the caudal end of ectolateralis by a gyrus and ectolateralis extends beyond the caudal border of the hemisphere. Any reduction in the length or depth of s. lateralis is likely to be compensated by changes in ectolateralis. The rostral end of lateralis is more variable and shallower than the caudal two-thirds. It usually

extends to the middle of the hemisphere, shifting to a more medial position and may end on the dorsal surface or extend around the medial border of the hemisphere and appear on the medial surface (Fig. 5, L.).

The s. ectolateralis (Fig. 1, Ecl.) (lateralis, Burkholder) is shallow and quite variable as to length and tends to appear as a series of detached depressions. In its simplest form as a continuous sulcus it occupies a position midway between lateralis and suprasylvius with its rostral end bounded by the gyrus just caudal to s. ansatus. In some brains its rostral end bifurcates, the medial branch ending at or near the medial border of the hemisphere or even appearing on the medial surface. It does not join suprasylvius or lateralis in its rostral portion.

The caudal third of s. ectolateralis, even its simplest form, varies greatly. It may reach the caudal pole of the hemisphere rarely, but is likely to be limited by a gyrus dorsal or medial to a ramus of s. suprasylvius (Fig. 4, S. S., 6) or be replaced by a series of shallow depressions quite variable in position. The simple form of the sulcus just described is in 50% of brains examined, replaced by a series of shallow depressions of which only the rostral portions have any degree of constancy. In no cases examined have two parallel depressions appeared representing s. ectolateralis. Even detached depressions indicate roughly the position of the simple form.

The s. suprasylvius (Figs. 1 and 4, S. S. A., S. S. M., S. S. P.) is a constant deep sulcus with convoluted walls and lies near the lateral border of the hemisphere forming an arch in its rostral third over the dorsal ramus of the f. of Sylvius and a gentler curve throughout its caudal two-thirds. It penetrates the brain wall in a ventromedial direction. In the rostral third of its extent it usually, just dorsal to the f. of Sylvius, gives off a shallow dorsal ramus (Figs. 1, S. S. 2) approaching or even joining s. ansatus and delimiting a triangular gyrus rostral to which it curves laterally (ventrally) around the lateral portion of s. ansatus beyond which it again curves medially usually ending in a bifurcation just caudal to s. diagonalis. Two rather frequent variations occur in this region. One due to the buried condition of the gyrus at the lateral border of s. ansatus which gives the appearance of a union of s. suprasylvius with the lateral border of s. ansatus and the other the continuation through a shallow groove of the rostral end of s. suprasylvius

(Figs. 1, S. S. 1) parallel with s. diagonalis. A connection between these two sulci is present in at least 50% of the brains examined but when present it is so shallow as not to alter the validity of Krueg's ('78) description of a constant s. diagonalis in the ungulates and invalidates Brodman's description (Kappers, p. 1187) of the s. diagonalis as an extension of the anterior ramus of s. suprasylvius in ungulates.

The s. suprasylvius presents a constant ventral ramus (Figs. 1 and 4, S. S. 5) varying in depth and sometimes connected by a shallow depression with the s. posticus. This ventral branch of s. suprasylvius varies in length and apparently in depth depending on the extent and depth of a dorsal ramus of s. posticus which lies when present just caudal to it. There is constantly present between this ramus and the f. of Sylvius a shallow depression (Fig. 1). The caudal end of the s. suprasylvius rarely reaches the caudal pole of the hemisphere. It usually ends in a bifurcation on the dorsolateral surface, the dorsal ramus of which may join the caudal end of the s. ectolateralis, the ventral branch usually joining the caudal end of the s. posticus. Any change in the bifurcation of the caudal end of the s. suprasylvius or the absence of fusions with s. ectolateralis and s. posticus are likely to be replaced by slight depressions of variable shape and depth.

The Rostral Surface.

(Fig. 2).

The constant sulci appearing on the rostral surface are the transverse sulci, ansatus (cruciatus) and splenialis, the horizontal sulci, coronalis, presylvius, diagonalis and the olfactory sulcus visible on depressing or detaching the olfactory bulb and tract.

The sulcus ansatus (Fig. 1 and 2 An.) is a deep sulcus with convoluted walls extending from the fissura longitudinalis, where it is visible on the median surface of the hemisphere, laterally nearly to sulcus suprasylvius from which it is separated by a curved gyrus which is sometimes buried giving the ansate sulcus the appearance of joining the sulcus suprasylvius. The s. ansatus penetrates the brain wall in a ventrocaudal direction so that the caudal wall forms an operculum over the rostral wall.

The sulcus splenialis (cruciatus? Krueg) described under the medial surface (Figs. 1 and 2 spl.) is quite constant and deep

varying only slightly in the degree to which it extends laterally from the longitudinal fissure.

The sulcus coronalis (Figs. 1 and 2 Co.) is the deepest sulcus on the rostral surface. Both medial and lateral walls are convoluted and the sulcus penetrates the brain wall in a ventrolateral direction, the lateral wall forming an operculum over the median wall. It begins caudally at the sulcus ansatus from which it extends rostrally sometimes bifurcating into lateral and medial rami but in most brains having only the lateral ramus, the medial ramus when absent is usually represented by a slight notch at the point of bifurcation. When the median arm is absent its position is sometimes indicated by a slight indentation (Figs. 1 and 2 Co. 1). The lateral ramus is always present and usually lies parallel with the rostral end of the presylvian sulcus. The walls of these rami both medial when present and lateral are convoluted.

The presylvian sulcus (Figs. 1 and 2 Prs.) is constant with convoluted walls and is nearly as deep as coronalis. It penetrates the brain wall in a dorsomedial direction. It ends between the rostral rami of coronalis when both are present or medial to the lateral ramus when the medial ramus is absent. The dorsal end of presylvius may sometimes join the lateral ramus of coronalis.

The olfactory sulcus (Fig. 2 Olf.) is visible on the rostral area when the olfactory bulb and tract are depressed or removed. It is a shallow sulcus in which the olfactory tract lies and is quite constant.

The sulcus rostralis (paraolfactorius, Burkholder) sometimes appears on the medial border of the hemisphere as a notch in f. longitudinalis about midway between ansatus and the rostral end of the brain.

The sulcus diagonalis (Figs. 1 and 2, D. A., D. 1.) lying on the lateral portion of the rostral area is always present but is quite variable in form. It is deep and its walls are usually convoluted. It penetrates the brain wall in a slightly ventromedial direction. Its simplest and most constant form is a nearly straight line beginning near the pars dorsalis of the Sylvian fissure and extending forward dorsally and medially nearly to the s. coronalis. It is usually separated from Sylvius and always from coronalis by well defined gyri. It is rarely continuous with suprasylvius as in some ungulates (Brodmann and Kappers ('21)). Continuity of these two sulci is some-

times indicated by a slight depression formed by a blood vessel. A more complicated form of diagonalis is represented by the presence of a ventral ramus (Figs. 1 and 2, D. 1.). This ventral ramus when present is almost as deep as the diagonal portion. When absent the ventral ramus is replaced by a detached sulcus. Sometimes the ventral ramus is continuous with a dorsal ramus (Figs. 4, S. A. 1.) of pars anterior of Sylvius or may even be replaced by it.

The Lateral Surface.

On the lateral surface of the brain all the constant depressions except the vertically placed f. of Sylvius have a general horizontal direction and even the f. of Sylvius has pronounced caudal and rostral rami lying horizontally.

The s. rhinalis (Figs. 3 and 4, R.) is quite constant in position and begins rostrally at the attachment of the olfactory tract to the ventral surface of the brain, extending caudally as a shallow groove to the level of the dorsal ramus of the f. of Sylvius where it becomes deep with convoluted walls and appears on the caudal surface of the hemisphere (Fig. 3, R.) extending sometimes almost to the dorsal border of the caudal surface.

The fissure of Sylvius (Figs. 4, S. D., S. A., S. P. 1) presents three constant portions. The terminology of Krueg ('78) and Kappers ('21) is adopted rather than that of Holl ('00). The pars dorsalis (Fig. 4, S. D.) (processus acuminis Krueg) extends almost to the dorsal border of the hemisphere. Its lateral walls are always deeply convoluted and sometimes show short depressions in the lateral walls running parallel with the floor of the main fissure. The caudal wall overlaps the rostral wall to some extent forming a slight operculum. The dorsal extremity of pars dorsalis occasionally bifurcates. Two additional anterior rami are sometimes found extending from the dorsal ramus of the f. of Sylvius. The more dorsal (Fig. 4, S. D. 1) may join the ventral ramus of the bifurcated s. suprasylvius and the more ventral ramus (Fig. 4, S. D. 2) may join the caudal end of the s. diagonalis.

The pars anterior is not only deep except at its anterior end but is much convoluted on both dorsal and ventral walls. This ramus penetrates the brain wall in a ventro-medial direction so that the buried portion of the dorsal wall is concealed by the ventral wall. The rostral end of this ramus usually

bifurcates and the ventral ramus (Fig. 4, S. A. 2) may be continuous by a shallow depression with the s. presylvius, while the dorsal ramus (Fig. 4, S. A. 1) sometimes joins the ventral ramus of s. diagonalis or replaces it. It is sometimes connected also with the presylvian sulcus by a shallow depression (Fig. 4, S. A. 3) at the level of the bifurcation.

The pars posterior of the f. of Sylvius is short, but deep with convoluted walls and presents two rami a caudal and a ventral both of which are constant, the ventral ramus (Fig. 4, S. P. 2) (transinsular fissure of Clark '96) joining rhinalis. This ventral ramus is the only deep sulcus reaching s. rhinalis. Other transverse depressions rostral to it are either quite shallow or simply depressions caused by blood vessels.

Holl ('00) who has made a study of the insula of the ungulate brain includes the ventral wall of the posterior ramus of the fissure of Sylvius and the gyrus lying ventral to the anterior ramus of the fissure of sylvius (gyrus orbitalis Burkholder) in the insula (gyrus arcuatus 1 Holl). The gyrus surrounding pars dorsalis is labeled (arcuatus II Holl). This gyrus is bounded dorsally by s. suprasylvius. It extends rostrally to the middle of the s. diagonalis and caudally to the caudal ramus of the s. suprasylvius and includes the gyri surrounding the s. posticus.

The presylvian sulcus (Fig. 4, Prs.) is constant and deep with convoluted walls, the dorsal wall forming an operculum over the ventral wall. The sulcus penetrates the brain in a ventro-medial direction. It begins usually just ventral to the rostral end of the anterior ramus of the f. of Sylvius. It may be connected as mentioned above by a shallow depression with the ventral branch of the bifurcated f. of Sylvius but is usually quite detached from it. It may appear sometimes to be connected also with f. of Sylvius more caudally at the level of the bifurcation but this connection (Fig. 4, S. A. 3) is quite inconsistent and shallow and is caused by a blood vessel. This sulcus (Figs. 1 and 2, Prs.) extends around the rostral pole of the hemisphere and ends on the rostral surface between the bifurcated branches of s. coronalis or when the medial ramus is absent, which frequently happens, at the extreme rostral tip of the hemisphere lying parallel with the lateral ramus of s. coronalis.

The suprasylvian or arcuate sulcus is the most extensive sulcus on the lateral surface. It is quite deep with convoluted

walls. This sulcus penetrates the brain in a slightly ventromedial direction especially in the pars media so that the ventral wall overlies the dorsal wall to some extent. It extends from just rostral to the pars dorsalis of the f. of Sylvius, in the form of an arch, almost to the caudal pole of the hemisphere. It is usually divided into a pars anterior (Figs. 1 and 4, S. S. A.) a pars media (Figs. 1 and 4, S. S. M.), a pars posterior (Figs. 1 and 4, S. S. P.) portions. The terminations of the anterior and posterior portions which are shallower than the pars media, being more variable in arrangement.

The pars media is the most constant and usually presents one shallow dorsal ramus, (Figs. 3 and 4, S. S. 2) directly dorsal to the end of the f. of Sylvius. As mentioned in describing the dorsal surface, the rostral portion of pars media (Fig. 4, S. S. C.) seems sometimes to be continuous with the lateral end of the s. ansatus owing to the depressing of the gyrus at the lateral termination of that sulcus.

The variations of pars anterior depend upon the form of the s. diagonalis. The pars anterior usually bifurcates into an anterior ramus (Fig. 4, S. S. 3) and a ventral ramus (Fig. 4, S. S. 4). Both rami are deep at the point of bifurcation and gradually become shallower toward their terminations. The anterior ramus rarely joins s. diagonalis and when this occurs it is by a shallow depression. In four cases, however, out of one hundred examined the depression was pronounced. The short ventral ramus (Fig. 4, S. S. 4) of the bifurcated rostral end may occasionally join and sometimes be replaced by a ramus from the f. of Sylvius (Fig. 4, S. D. 1) in the same relative position.

The caudal border of the pars media of s. suprasylvius is indicated by a constant and fairly deep ventral ramus (Fig. 4, S. S. 5). It is never entirely absent but varies in length and depth depending on the depth and form of s. posticus. From this ventral ramus the pars posterior forms a gentle curve maintaining its depth and convoluted wall almost to the caudal border of the hemisphere. The caudal portion of this sulcus is quite variable but usually bifurcates into a dorsal ramus (Fig. 4, S. S. 6) which frequently reaches the caudal border and is connected sometimes with the caudal end of s. ectolateralis (Fig. 4, Ecl.) or with detached depressions in the usual position of the caudal end of that sulcus. The ventral ramus (Fig. 4, S. S. 7) is still more variable but rarely absent and may be

connected with the caudal ramus of s. posticus and when absent be replaced by a branch from s. posticus.

The s. diagonalis (Fig. 4, D. A., D. P.) is a constant deep sulcus and penetrates the brain in a ventromedial direction. In 75% of the brains examined it is a simple diagonal depression beginning caudally near the middle of pars dorsalis of the f. of Sylvius and extending diagonally, rostrally and medially nearly to the middle of s. coronalis with which it never forms a junction. The caudal end of the sulcus is occasionally continuous with the f. of Sylvius by a transient anterior ramus of that fissure (Fig. 4, S. D. 2). This simple form of the diagonal sulcus is always accompanied by slight depressions both ventral and dorsal to the main sulcus. Owing to the presence of a ventral ramus in 25% of the cases examined the anterior and posterior halves are indicated as ramus anterior (Fig. 4, D. A.) and ramus posterior (Fig. 4, D. P.) respectively. In 25% of the brains examined there is a ventral ramus (Figs. 1, 2 and 4, D. 1) arising near the middle of the s. diagonalis and extending ventral and cephalad sometimes joining the anterior ramus (Fig. 4, S. A. 1) of the Sylvian fissure. This ramus is not as deep as the anterior and posterior rami and when absent is replaced by the slight depression mentioned above. The slight dorsal depression (Fig. 4, D. 2) mentioned above is sometimes continuous with the anterior ramus of diagonalis.

The s. posticus is a deep sulcus present in all brains examined and usually presents an anterior, a posterior and a somewhat inconstant and shallower dorsal ramus and a similar ventral ramus. In a few cases the anterior and posterior portions are detached from each other and the detached portions with the dorsal and ventral rami form a stellate figure. The anterior and posterior rami are the deepest and most constant portions. The anterior ramus (Fig. 4, P. A.) extends rostrally nearly to the f. of Sylvius which, however, it never joins. It usually ends just ventral to the ventral ramus (Fig. 4, S. S. 5) at the caudal border of pars media of s. suprasylvius. The caudal ramus extends nearly to the caudal border of the hemisphere and frequently bifurcates, its dorsal ramus sometimes joining s. suprasylvius (Fig. 4, S. S. 7). When the caudal ramus is short its caudal portion is replaced by a detached shallow depression. The dorsal and ventral rami (P. D., P. V.) are more variable than the anterior and posterior rami. The dorsal ramus is rarely absent, is short and deep and is

situated more cephalad than the ventral ramus. The ventral ramus (Fig. 4, P. P.) is sometimes absent and is replaced by a detached depression occupying the same relative position.

The Medial and Caudal Surfaces.
(Figs. 3 and 5).

The caudal and concealed portions of the medial surfaces of the hemisphere are exposed by a transverse incision and removal of the brain stem at the level of the mammillary body.

On the buried medial surface of the hemisphere two depressions, the hippocampal fissure and fimbriodentate sulcus appear constantly. Both are shallow even the hippocampal fissure cannot be readily opened.

The fimbriodentate sulcus (Fig. 5, Fd.) lies rostral to the hippocampal fissure between the fimbria and the gyrus dentatus and extends throughout the whole arch of the buried portion of the hemisphere appearing on the flat medial surface in front of the more anterior of two prominent elevations of gray matter ventral to and slightly rostral to the splenium of the corpus callosum.

The hippocampal fissure (Fig. 5, H.) lies caudal to the fimbrio-dentate sulcus between the gyrus dentatus and the gyrus hippocampi and extends throughout the whole arch of the buried medial surface of the hemisphere. It appears on the flat medial surface of the hemisphere when a median longitudinal section of the brain is made and is visible between the two small gray elevations mentioned above. These two gray elevations are usually labeled in the text books as fasciola cinerea. The anterior of these two gray masses is the dorsal limit of the gyrus dentatus and the posterior elevation is a continuation of the gyrus hippocampi.

On the flat medial surface of the hemisphere four sulci are always present with slight variations to be mentioned later with the addition of transient sulci belonging to the dorsal surface of the hemisphere.

The sulcus corporis callosi (Fig. 4, C.) is constant but shallow and extends throughout the length of the dorsal border of the corpus callosum and well around both genu and splenium.

The rostral area of the medial surface presents two constant moderately deep sulci: the s. genualis (Fig. 5, G.) of Krueg and Kappers (s. cinguli Burkholder) and the more rostral s.

rostralis (Fig. 5, Ro.) of Krueg and Kappers (parolfactorius Burkholder).

The sulcus genualis (Fig. 5, G.) begins cephalad ventral to the genu of the corpus callosum and arching around the corpus callosum extends to the middle of that structure. It is sometimes quite simple in structure but often presents a well defined dorsal ramus (Fig. 5, G. 1) just rostral to the anterior end of s. splenialis and sometimes a ventral ramus (Fig. 5, G. 2). This dorsal ramus may be absent or represented by a slight depression and may occasionally be situated more rostral and invade the area usually occupied by s. rostralis.

The s. rostralis (Fig. 5, Ro.) is more variable than genualis. In its most regular form it parallels the course of s. genualis lying nearer the rostral border of the hemisphere forming an arch beginning ventral to the rostral end of s. genualis and arching around extends caudally to the gyrus just rostral to the s. splenialis where it may reach the edge of the hemisphere. Its variations consist in its appearing as two detached depressions in some cases and occasionally in the detached portions being separated by a ramus of s. genualis.

A constant sulcus (Fig. 5, Pc.) appears caudal to the splenium of the corpus callosum occupying the same relation to the splenium that s. genualis occupies with reference to the genu. It is a short sulcus and varies both in depth and length and when least pronounced is represented by a slight depression. It is not named in any description of the sheep brain. It is indicated in many ungulate brains by Krueg ('78) and occupies the position of the subparietoccipital fissure of the anthropoids. Since the sulcus is always present it is named from its position sulcus post callosus, since the term retrosplenialis is preempted. Its position indicates that it is in an olfactory area (regio retrosplenialis of Campbell).

The sulcus splenialis (Fig. 5, Spl.) is the most extensive and deepest sulcus on the medial surface of the hemisphere and is much convoluted in its caudal half. It has a well defined diagonal direction ventrolaterally as it penetrates the hemisphere so that its ventral wall forms an operculum over its dorsal wall. It begins rostrally on the dorsal surface of the hemisphere (Figs. 1 and 3, Spl.) just in front of the s. ansatus and extends in an arch below the dorsal border of the hemisphere to the caudal border where it bifurcates into a dorsal and ventral ramus, the ventral ramus (Figs. 3 and 5, R. S.) being the sulcus

retrosplenialis of Kappers and the dorsal ramus (Figs. 3 and 5, H. P.), which is frequently shorter and shallower, being the ramus horizontalis posterior of Kappers. These two rami are never absent in the brains examined but vary somewhat in length and depth. A rather common variation in the rostral portion of s. splenialis is the presence of a dorsal ramus (Fig. 5, Spl. 1) frequently reaching the dorsal border of the hemisphere and lying just caudal to the s. ansatus (Fig. 5, An.) and between that sulcus and the s. lateralis when it reaches the medial border of the hemisphere.

On the caudal surface of the hemisphere the s. rhinalis (Figs. 3 and 5, R.) is always present. Sometimes it ends well toward the lateral surface of the caudal area and may be continuous with the caudal end of s. suprasylvius. In other cases it lies more medial and is in one brain continuous with the caudal end of s. lateralis of the dorsal surface. These variations seem to be correlated with the form and extent of a third sulcus which Kappers ('21 p. 1126) calls the occipito-temporal sulcus. This is sometimes a detached sulcus in the sheep but is frequently represented by the caudal extension of s. lateralis. The modeling of the caudal surface is usually determined by the length and depth of the ramus horizontalis posterior, s. lateralis and s. rhinalis. When the simpler arrangements are not present, that is, well pronounced caudal extensions of splenialis, lateralis and rhinalis detached depressions occur. The s. occipitotemporalis is best defined when lateralis is short and does not appear on the caudal surface of the hemisphere. This indicates a close relation between occipitotemporalis when present and s. lateralis. When occipitotemporalis is best defined it lies parallel and between retrosplenialis (Fig. 3, Rs.) and rhinalis (Fig. 3, R.).

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EXPLANATION OF PLATES.

In all figures primary or deep sulci and fissures are indicated by heavy lines, shallow sulci are indicated by fine lines, transient sulci are indicated by broken lines. A shallow sulcus is likely to be transient, but when it is of value as a landmark in localization it is sometimes indicated by a fine line and its transient character is noted in text.

Plate I.

Fig. 1. Dorsal surface × 1.75.

Fig. 2. Rostral surface × 1.5.

Fig. 3. Caudal surface × 1.5. Fig. 3, in order to show the relation of sulci on the caudal surface to sulci on other surfaces includes more than the area in contact with the cerebellum which is taken as the caudal surface. The sulci shown in Fig. 3 are visible after the removal of the cerebellum.

Plate II.

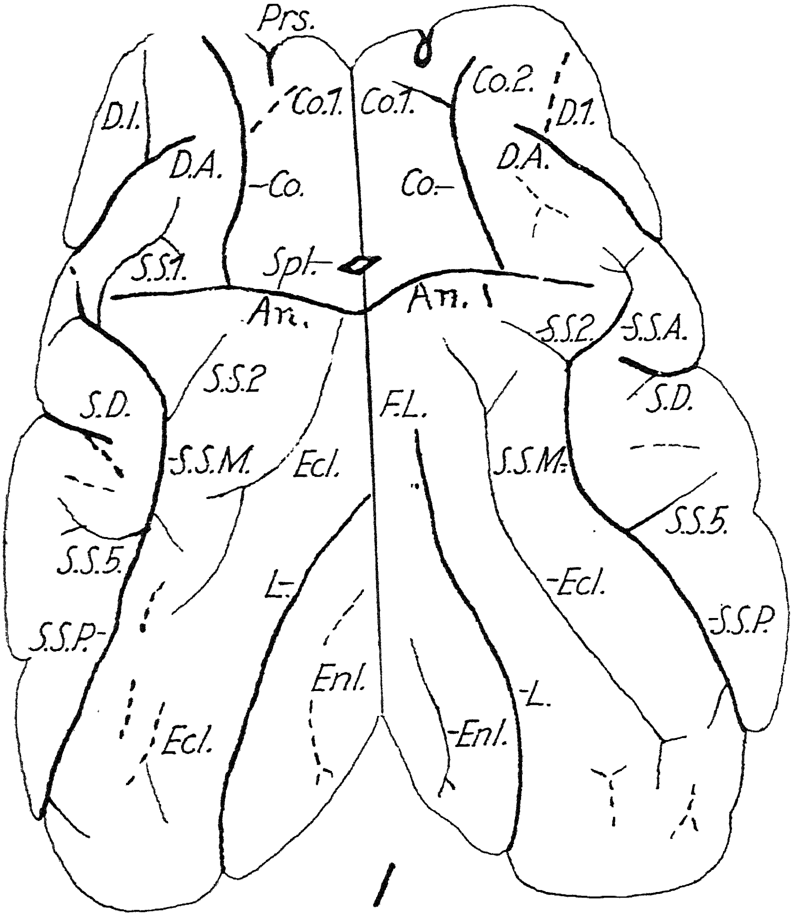
Fig. 4. Lateral surface × 1.75.

Fig. 5. Medial surface × 1.75. The brain stem was removed by a transverse incision at the level of the mammillary body.

Note.—The determination of the relative depth of sulci on formalin fixed material is easily accomplished by immersing brains in tap water for some time, when the hemisphere wall becomes flexible and gyri are easily opened.

ABBREVIATIONS.

An.	sulcus ansatus (cruciatus?).
C.	sulcus corporis callosi.
C. A.	commissura anterior.
C. C.	corpus callosum.
C. O.	sulcus coronalis.
C. O. 1.	sulcus coronalis, ramus medialis.
C. O. 2.	sulcus coronalis, ramus lateralis.
D. A.	sulcus diagonalis, ramus anterior.
D. P.	sulcus diagonalis, ramus posterior.
D. 1.	sulcus diagonalis, ramus ventralis.
D. 2.	sulcus diagonalis, ramus dorsalis.
Ecl.	sulcus ectolateralis.
Enl.	sulcus entolateralis.
Fd.	sulcus fimbriodentatus.
F. L.	fissura longitudinalis.
For.	fornix.
G.	sulcus genualis (cinguli).
G. 1.	sulcus genualis, ramus dorsalis.
G. 2.	sulcus ganualis, ramus ventralis.
H.	fissura hippocampi.
H. P.	sulcus splenialis, ramus horizontalis posterior.
L.	sulcus lateralis.
M.	massa intermedia.
O. B.	bulbus olfactorius.
Oct.	sulcus occipitotemporalis.
Olf.	sulcus olfactorius.
P. A.	sulcus posticus, ramus anterior.
Pc.	sulcus postcallosus.
P. P.	sulcus posticus, ramus posterior.
P. D.	sulcus posticus, ramus dorsalis.
P. V.	sulcus posticus, ramus ventralis.
Prs.	sulcus presylvius.
R.	sulcus rhinalis.
Ro.	sulcus rostralis (paraolfactorius).
Rs.	sulcus retrosplenialis.
S.	septum pellucidum
S. A.	fissura Sylvii, pars anterior.
S. A. 1.	fissura Sylvii, pars anterior, ramus dorsalis.
S. A. 2.	fissura Sylvii, pars anterior, ramus medialis.
S. A. 3.	fissura Sylvii, pars anterior, ramus ventralis.
S. D.	fissura Sylvii, pars dorsalis.
S. D. 1.	fissura Sylvii, pars dorsalis, ramus dorsalis.
S. D. 2.	fissura Sylvii, pars dorsalis, ramus ventralis.
S. P. 1.	fissura Sylvii, pars posterior.
S. P. 2.	fissura Sylvii, pars posterior, ramus ventralis.
Spl.	sulcus splenialis.
Spl. 1.	sulcus splenialis, ramus dorsalis.
S. S. A.	sulcus suprasylvius, pars anterior.
S. S. 1.	sulcus suprasylvius, pars anterior, ramus anterior.
S. S. 3.	sulcus suprasylvius, pars anterior, ramus medialis.
S. S. 4.	sulcus suprasylvius, pars anterior, ramus ventralis.
S. S. M.	sulcus suprasylvius, pars media.
S. S. 5.	sulcus suprasylvius, pars media, ramus ventralis.
S. S. 2.	sulcus suprasylvius, pars media, ramus dorsalis.
S. S. P.	sulcus suprasylvius, pars posterior.
S. S. 6.	sulcus suprasylvius, pars posterior, ramus dorsalis.
S. S. 7.	sulcus suprasylvius, pars posterior, ramus ventralis.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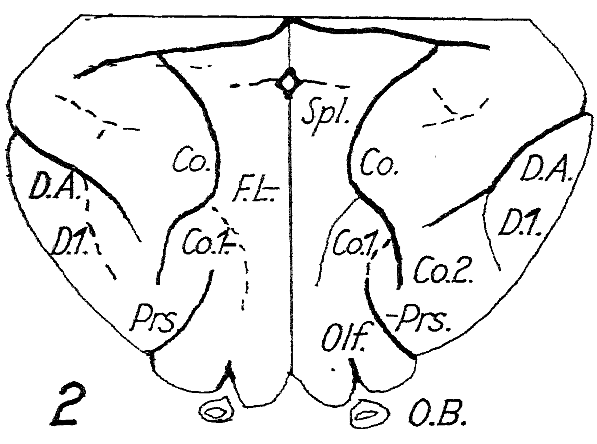
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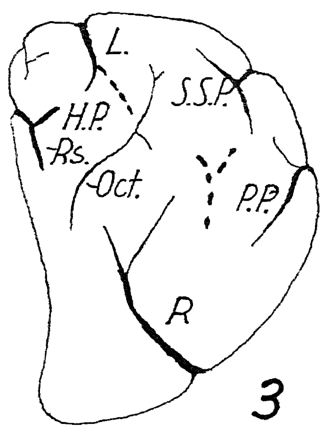
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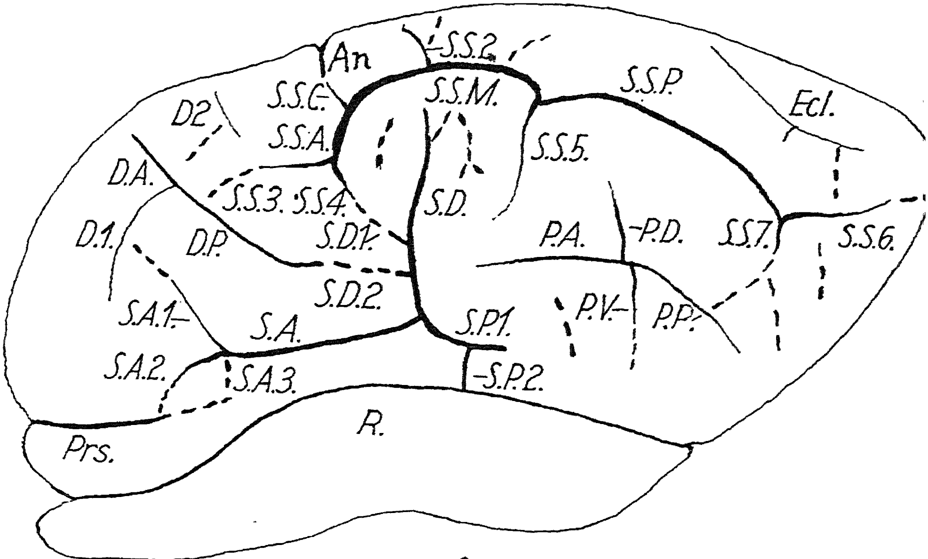
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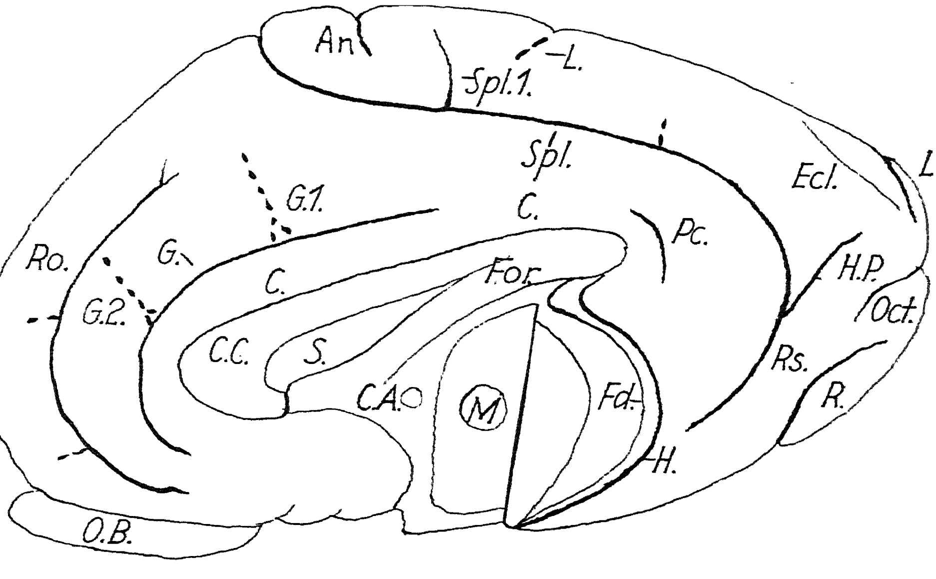
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5

ADDITIONAL SPECIES FROM THE SILICA SHALE OF LUCAS COUNTY, OHIO.

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INTRODUCTION.

Since the publication of my earlier study on the Fauna of the Silica Shale of Lucas County, in 1927* additional collecting from this shale over a period of two years has yielded eight more species. These are represented by very few specimens, but it seems worth while to record them inasmuch as three of them are apparently new. The species described in this paper are: *Favosites nitella; Stropheodonta demissa var.; Terebratula mediocris* n. sp.; *Leiorhynchus kelloggi; Tornoceras uniangularis; Isochilina scapha* n. sp.; *Leperditia* (?) *subrotunda* (?); *Bythocypris indianensis.*

An excavation on the floor of the quarry of the Sandusky Cement Company within the past year has revealed an additional two and a half feet of the Silica shale. This shale is not continuous with that above but is separated from it by an eight-inch limestone layer which forms the quarry floor at the north end. No systematic collecting has been done from this lower shale horizon but so far as observed there is no marked variation in the faunal content from that in the shale above.

DESCRIPTION OF SPECIES.

PHYLUM *COELENTERATA*

CLASS *ANTHOZOA*

SUBCLASS *TABULATA*

Genus **Favosites** Lamarck

Favosites nitella Winchell

(Plate I, Fig. 1.)

1866. *Favosites nitella* Winchell, Rept. Low. Pen. of Mich., p. 89.
1876. *Favosites nitella* Rominger, Geol. Surv. Mich., Vol. III, Foss. Corals, p. 33. Pl. XI, Fig. 4.
1899. *Favosites nitella* Lambe, Contrib. to Can. Palaeon., Vol. IV, Pt. 1, p. 17.

*Stewart, Grace A. Geol. Surv. Ohio, Bull. 32, 1927.

Rominger's Description, 1876.—"Tubes rounded-polygonal, subequal, stout-walled, not fully one millimeter in width. Tube channels smooth or beset with distant lateral squamæ. Diaphragms partially simple, regular, partially of complicated irregular form through intersection with the lateral squamæ. Pores large, distant, in a single row on each side. Mode of growth globular or pyriform or digitato-ramose."

Remarks.—One discoidal colony attached to an Atrypa shell conforms very well with the characters of this species. The specimen is about 2 inches in diameter. The corallites are prismatic, small, scarcely a millimeter in diameter. Here and there are interspersed larger, circular tubes slightly more than a millimeter across. The pores and squamæ are imperfectly shown. The species has been found quite abundantly at higher horizons in the Devonian formations of Northwest Ohio.

PHYLUM *MOLLUSCOIDEA*

CLASS *BRACHIOPODA*

ORDER *PROTREMATA*

Genus **Stropheodonta** Hall

Stropheodonta demissa var.

(Plate I, Fig. 2.)

A few specimens of *Stropheodonta demissa* (Conrad) are at hand which are not entirely typical of the species, in that they do not have the striations stronger and more elevated on the umbo of the valves and becoming distinctly smaller and more numerous from there to the margin. Instead the striations bifurcate very close to the beak, and then are uniformly strong and of the same size until very close to the margin. Here they bifurcate and become much finer, and additional fine striæ are intercalated between them. A few striations bifurcate midway between the umbo and anterior margin.

Because of these differences the specimens are considered to represent a variety of the typical species.

Figured specimen, No. 16532, Geological Museum, Ohio State University.

Order *Telotremata*

Genus **Leiorhynchus** Hall

Leiorhynchus kelloggi Hall

(Plate I, Figs. 3, 4).

1867. *Leiorhynchus kelloggi* Hall, Pal. New York, Vol. IV, p. 361, Pl. 57, Figs. 1–12.
1893. *Leiorhynchus kelloggi* Hall and Clarke, Pal. New York, Vol. VIII, Pt. II, p. 194, Pl. 59, Figs. 18–20, 32, 33.

Description.—Shell of moderate size; biconvex; transversely ovate to suborbicular; slightly wider than long, although in some cases the length and width are equal. Cardinal margins meeting beak at obtuse angle; lateral margins rounding uniformly to the anterior margin which is sinuate. The dimensions of an average sized specimen are: Length 25 mm., width 26 mm. A more orbicular specimen has a length and width of 24 mm.

Pedicle valve moderately to strongly convex on the umbo, flattening out on the lateral slopes, and anteriorly becoming depressed into a wide flaring sinus. Beak small, erect, rising only slightly above the brachial beak, perforated by a small foramen. Brachial valve more convex than the pedicle, curving regularly to the lateral margins; about the middle of the shell developing a low, broadly expanding fold. Beak curving under that of the pedicle valve. A median septum, with elongate muscle scars on either side, is present on the interior of the brachial valve.

Each valve marked by low, rounded, radiating plications which are usually less distinct in the umbonal region; commonly five or six are in the sinus, and an equal number on the fold, but occasionally as many as ten have been noticed. Six or seven poorly developed plications are present on the lateral slopes. Fine concentric striations are present on well-preserved specimens, and in some cases less distinct radiating ones are also present.

Remarks.—This species was originally described by Hall from specimens which came from the Olentangy shale in the northern part of Ohio, where they have been found in profusion in some places. Only two or three specimens have been found in the shale pit of the Sandusky Cement Company at Silica, but an abundance of them have been found at other horizons of the Devonian in northwest Ohio. Along Tenmile creek just south of Silica, some shaly limestone blocks dredged up from the bottom of the creek have yielded numerous excellent specimens. Stratigraphically this limestone is about twenty-five feet above the Silica shale of the Sandusky Cement Company quarry. The specimens are identical with those described by Hall from the Olentangy shale on the east side of the anticline.

The shape, small erect beak, and the weak development of the plications on the umbonal region are outstanding characters of the species.

Genus **Terebratula** Klein.

Terebratula mediocris n. sp.

(Plate I, Figs. 5-7.)

Description.—Shell of moderate size; rostrate, biconvex, elongate ovoid in outline; becoming flattened anteriorly, with evenly rounded anterior margin. The dimensions of the type specimen are: Length, 20 mm., width, 16 mm., with the greatest width anterior to the middle of the shell.

Pedicle valve moderately and uniformly convex from the beak to a little beyond the middle and then flattening quite noticeably to the anterior margin. Beak arcuate, rising some distance above the beak of the opposite valve; moderately incurved; perforated by a round foramen. Deltidial plates closing the greater part of the delthyrium. Cardinal slopes rounded.

Brachial valve shorter than the pedicle valve, moderately convex, the greatest convexity in the middle of the valve; depressed slightly anteriorly. Beak low, incurved below the beak of the opposite valve.

Surface of both valves marked by fine concentric growth lines, which near the anterior margin become crowded into rather prominent wrinkles. Shell structure finely punctate. Internal characters not observed.

Remarks.—Only one specimen of this species has been collected. It appears to be a well-marked species since it does not entirely conform to any described species of the genus known to the writer. The specimen most closely approaches *Terebratula sullivanti* Hall, from which it differs in its greater convexity, and in having an evenly rounded anterior margin instead of an emarginate one. From *Terebratula roemingeri* Hall it differs in the larger size. It resembles *Terebratula harmonia* Hall but that species is flatter and the beak is more erect.

Holotype, No. 16534, Geological Museum, Ohio State University.

PHYLUM *MOLLUSCA*

CLASS *CEPHALOPODA*

ORDER *AMMONOIDEA*

Genus **Tornoceras** Hyatt

Tornoceras uniangularis (Conrad)

(Plate I, Figs. 8, 9.)

1842. *Goniatites uniangularis* Conrad, Jour. Acad. Nat. Sci. Phila., Vol. 8, p. 268, Pl. 16, Fig. 4.
1879. *Goniatites uniangularis* Hall, N. Y. Palaeon., Vol. V, Pt. 2 (1), p. 444, Pl. 71, Fig. 14; Pl. 72, Figs. 6, 7; Pl. 74, Fig. 2.

Description.—Shell small, discoidal, having a diameter of about 12 mm. Only about two volutions are present on the specimen examined, but according to Hall a complete mature specimen probably has about four. Whorl section broadly oval, the dimensions on a septum near the living chamber being: Width 5 mm.; height 4 mm. Lateral surfaces almost flat.

Volutions compressed, gradually enlarging in size, in close contact, each one being deeply impressed on the preceding one. Umbilicus a small shallow depression. Living chamber not preserved, so that character of aperture is not known.

Well defined sutures on the cast of the interior mark the edges of the septa, and show the outline of the numerous cameræ. The sutures are a series of lobes and saddles, closely arranged at the umbilical margin, diverging and curving towards the aperture to form prominent saddles, then recurving to form deep lateral lobes; on the ventrilateral margins the saddles are shallower and narrower than on the lateral surface; the ventral lobe is narrow and conspicuously pointed.

Siphuncle not well shown on the specimen examined, but specimens of this species from elsewhere show it to be small and situated just beneath the test on the ventral side, and expanding anteriorly between the adjacent septa.

Shell characteristics not observed.

Remarks.—Only one small incomplete specimen of this neat little cephalopod has been obtained from the Silica shale, but it preserves very well the outstanding characteristics of the species. The species has not been recorded previously from the Devonian rocks of Ohio, but has been reported from the Hamilton and Portage shales of New York, and from rocks of Hamilton age in western Canada. The compressed state of the whorls and the prominent curving and recurving of the sutures to form saddles and lobes are the characters used in identifying this species.

PHYLUM *ARTHROPODA*

CLASS *CRUSTACEA*

SUBCLASS *OSTRACODA*

Genus **Leperditia** Rouault

Leperditia (?) subrotunda (?) Ulrich

(Plate I, Fig. 10.)

1890. *Leperditia (?) subrotunda* Ulrich, Cinc. Soc. Nat. Hist., Vol. 13, p. 181, Pl. 16, Figs. 1a, b, c.

One incomplete right valve with a portion of the anterior end missing is insufficient for accurate specific determination, and is doubtfully referred to this species. The specimen is small having a length of about 1.50 millimeters, and a height of 1 millimeter, the greatest height occurring almost in the middle of the shell. Valve moderately convex and more or less depressed toward the margin all the way round. Dorsal edge straight, curving with somewhat rounded angles to the anterior and posterior margins; ventral margin slightly triangular. Anterior margin more projecting and less broadly rounded than the posterior. Sub-centrally the shell is marked by a rounded muscle imprint; otherwise the surface is smooth and shows no indication of an eye tubercle.

This little shell is most closely connected with *Leperditia (?) subrotunda* Ulrich in its appearance, but is relatively wider, and the ends are more narrowly rounded.

Genus **Isochilina** Jones

Isochilina scapha n. sp.

(Plate I, Figs. 11, 12.)

Description.—Carapace very small, transversely elongate, canoe-shaped in form. Viewed dorsally the shell is elliptical in outline, the posterior end swollen in appearance as contrasted with the thinner anterior end. The dimensions of a perfect specimen are: Length 1.25 mm.; height .75 mm.; thickness, .50 mm. Valves moderately and evenly convex, the right one flattened a little marginally except along the dorsal edge. Dorsal margin straight or very slightly convex, merging into moderately rounded cardinal angles of which the anterior is the sharper of the two. Ventral margin straight, curving gradually into the rounded ends, the posterior end being more broadly rounded than the anterior. An oval sulcus occurs along the hinge. Surface smooth and even, with no sign of either muscle spot or eye tubercle.

Remarks.—This species is represented in our collections by one perfect specimen. It approaches *Isochilina fabacea* Jones

in its characters, but it does not have the finely reticulate surface of that species, and the ends are more uniformly rounded.

Holotype, No. 16538, Geological Museum, Ohio State University.

Genus **Bythocypris** Brady

Bythocypris indianensis Ulrich

(Plate I, Fig. 13.)

1890. *Bythocypris indianensis* Ulrich, Journ. Cinc. Soc. Nat. Hist., Vol. 13, p. 197, Pl. 16, Figs. 11a, b, c.

Description.—A small slender carapace having a length of about 1 millimeter and a height of .75 millimeters. Biconvex, subovoid, transversely oblong, the ends unequal. Left valve the larger and overlapping the right, the greatest overlap on the dorsal margin. Dorsal margin arched, postero-cardinal angle more pronounced than the other. Ventral margin slightly convex, curving to the ends of which the posterior is the more blunt. Eye tubercle distinct, a little anterior to the center in position. Surface smooth.

Remarks.—A few minute specimens have been collected from the Silica shale which in their general characteristics agree very well with this species. Stauffer questionably reported the species from the Devonian beds in northwest Ohio.

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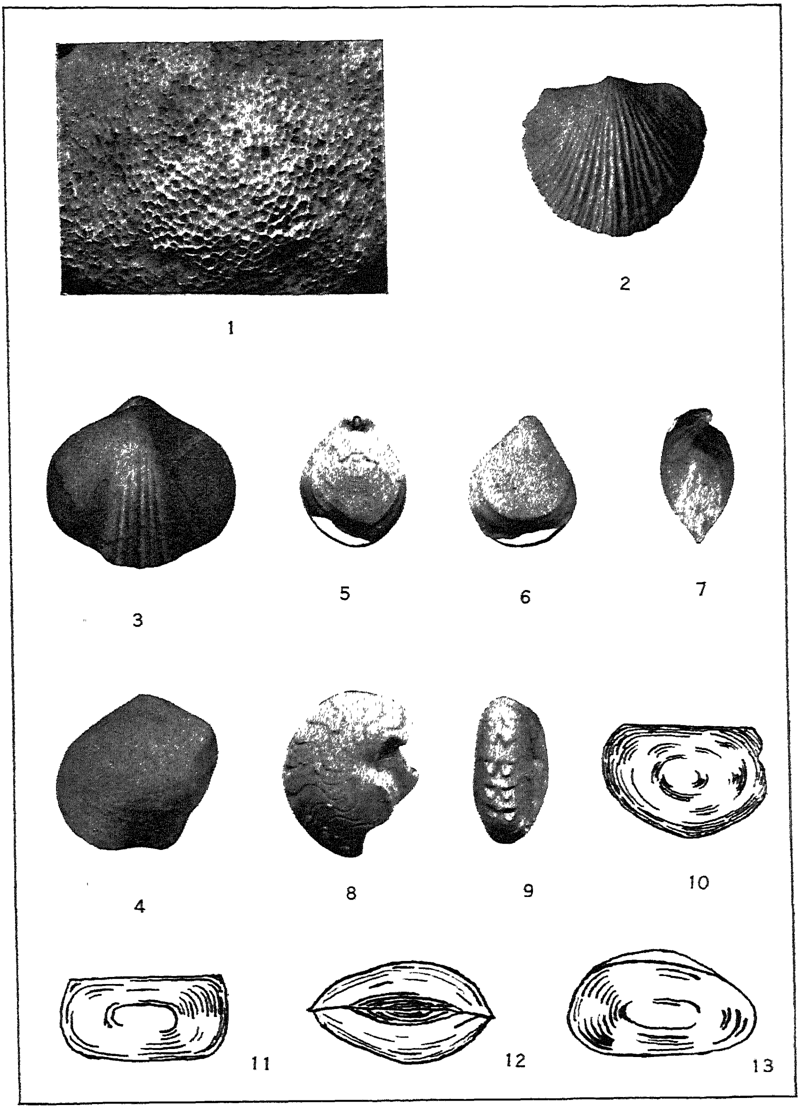
Species from Silica Shale of Lucas County
Grace Anne Stewart

PLATE I.



ORTHOGENETIC SERIES RESULTING FROM A SIMPLE PROGRESSIVE MOVEMENT*.

Studies in Determinate Evolution III.

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The five cases of orthogenetic series presented below will illustrate the general principle evident in endless numbers of characters from one end of the plant kingdom to the other. The progression in perfection of the main characteristic of each series apparently depends on the progressive evolution of a single mutative property, except in the last example given, which appears to involve several additional harmonious movements before the extreme is reached. As intimated in a previous paper, although the series in each case probably represents some of the actual evolutionary steps which the highest members took in attaining to their advanced condition of perfection, we are at present not so much concerned with the details of the actual movement as we are in presenting the phenomena of the series for consideration. For it is self-evident that no theories of heredity and no theories of evolution are worthy of serious consideration by the scientist, who is attempting to fathom some of the mysteries of nature, unless they take these things into account. At present, almost any presentation, even though based on the most profoundly irrational philosophy and taking no account of the volume of biological knowledge so far amassed and tested as to its reality, when masquerading under the name of science and assumed authority, is able to take possession of the very citadel of scientific education. The plant taxonomies, for example, which are persistently perpetuated offer a most profound contradiction to any rational theory of evolution. Yet it is practically impossible to get a manual of plants which shows any influence whatever of the modern phylogenetic studies. To continue to use a system of taxonomy which makes evolution untenable and at the same time teach the subject as a scientific

* Papers from the Department of Botany, The Ohio State University, No. 243.

dogma is like persisting in the belief that the world is the flat fixed center of the universe and at the same time teaching the unfortunate student that the earth revolves around the sun. A correct taxonomy is the first requirement of a correct understanding of evolution just as much as a correct evolutionary viewpoint is a necessary basis for a correct taxonomy. The two are interdependent. The same may be said in relation to evolution and genetics. A genetics which does not go parallel with phylogenetic taxonomy is no genetics at all.

1. A PROGRESSIVE SERIES IN THE REDUCTION OF THE CARPELLATE BRACT OF ABIES.

(See Figure 1).

The reduction of the leaf blade of the sporophyll is evident in many independent groups of vascular plants, and not only is this reduction manifest in the individual series but there is a consistent progression in the reduction in the entire series of vascular plants from the lowest ferns to the highest composites. The example given shows this progression in the fir. The same characteristic progression can be traced in other groups of conifers having ovuliferous scales. In Abies the movement is very prominent.

In the bristle-cone fir (*Abies venusta* (Dougl.) Koch. (Fig. 1-a) the carpellate bract is about three times as long as the ovuliferous scale and is still very leaf-like in texture. *Abies nobilis* Lindl. (Fig. 1-b) shows a considerable change, the carpellate bract being less than twice as long as the ovuliferous scale, and in *Abies fraseri* (Pursh) Poir. (Fig. 1-c) the reduction is still greater. In *Abies cephalonica* (Endl.) Loud. (Fig. 1-d) the carpellate bract is shorter than the ovuliferous scale and decidely membranous. The final steps, represented by *Abies grandis* Lindl. (Fig. 1-e), and *A*, *lasiocarpa* (Hook.) Nutt. (Fig. 1-f), bring the carpellate bract down to a mere vestigial appendage at the base of the ovuliferous scale. All the species of fir will come into this series in this respect, ranging from the bristle-cone fir to the alpine fir. In the firs the prominent ovuliferous scale remains fairly uniform, but the reduction of the carpellate bract has no relation to the uniformity of the ovuliferous scale. The carpellate blade or bract shows an orthogenetic reduction also in groups in which the ovuliferous scale is evolving to a great size as well as in groups in which no ovuliferous scale whatever is developed.

The progressive reduction of the carpellate bract might be considered morphologically as an evolution backward or as a loss of something that was formerly possessed, but this would be an entirely superficial and erroneous point of view. The evolution is through the acquirement of a progressive potentiality of the protoplast. The carpellate bract is a leaf. In the lowest vascular plants with a simple hereditary system, the homologous lateral appendages, differentiated as foliage leaves and sporangium-bearing leaves, are essentially alike. The

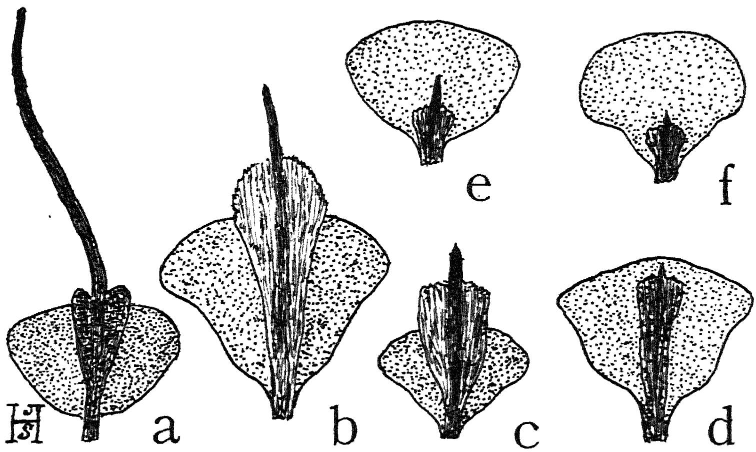


FIG. 1. Carpels of species of fir showing reduction in the size of the carpellate bract. a, *Abies venusta* (Dougl.) Koch., Bristlecone Fir. b, *A. nobilis* Lindl., Noble Fir. c, *A. fraseri* (Pursh) Poir., Fraser Fir. d, *A. cephalonica* (Endl.) Loud., Cephalonian Fir. e, *A. grandis* Lindl., Grand Fir. f, *A. lasiocarpa* (Hook.) Nutt., Alpine Fir. All Figures natural size.

evolution progresses step by step in producing a more complex reaction system until the degree of difference is very great, as in the alpine fir. The difference is not due to a loss of anything but to the evolution of a more complex reaction system which can, from homologous leaf incepts, bring out not only an ordinary foliage leaf but also a highly specialized woody-membranous bract. In the lower firs the resemblance to a leaf is still considerable, in the more advanced species the resemblance is slight, while in very highly evolved plants the resemblance becomes unrecognizable.

Now this loss of leaf character of the megasporophyll is of no advantage or disadvantage to the plant, neither is there any advantage or disadvantage in the different lengths of this

vestigial organ to the different species of Abies. If the plant had few leaves the early loss of chlorophyll in any part might be a disadvantage but firs have an abundance of leaves so the extra food is not needed. Any utilitarian or selective explanation offered as a causative agent to account for this orthogenetic series would have to be dismissed as the childish guess of credulity.

2. THE PROGRESSIVE ENLARGEMENT AND PERFECTION OF THE AWN AND SPIKELET OF STIPA.

(See Plate I).

Just as the preceding case was a progression in the reduction of the sporophyll, so the present series represents an increase in the development of the lemma or outer flowering glume. Stipa is a highly evolved genus of grasses and we are, therefore, prepared for the development of a highly bizarre type of fruit, not because this type of fruit with its indurated flowering glumes, its sharp-pointed callus, and its remarkable awn, twisted and plumed, are peculiar to this group, they are evolved in many independent lines, but because when the protoplast becomes full of certain highly evolved potentialities the progression very commonly ends in very remarkable forms, which from one point of view may be regarded as abnormalities or freaks. Many of the remarkable characteristics of man himself belong to this category. Of course, this language is not to be interpreted as meaning that these forms have not come through the orderly progression of evolution but only that in them a large number of orthogenetic movements have culminated. Apparently the protoplast with a complex hereditary potentiality is more subject to large and extreme mutations than the protoplast which is comparatively unevolved and thus has comparatively few hereditary potentialities or complexities.

The fruits illustrated represent the entire mature spikelet as it falls out of the empty glumes. Figure 1 represents the fruit of *Stipa macounii* Scribn. This is a rather small structure whose parts could be duplicated in many other groups of grasses. It has only a short awn and the lower awl-point is not conspicuous. Nevertheless it has nearly all of the characteristics of the highly evolved species except the plumose hairs on the awn. *Stipa scribneri* Vas. (Fig. 2) and *Stipa viridula* Trin. (Fig. 3.) show considerable improvement in the structure and

this improvement is carried forward consistently through *S. robusta* (Vas.) Scribn. (Fig. 4), *S. occidentalis* Thurb. (Fig. 5), *S. avenacea* L. (Fig. 6), and *S. tweedyi* Scribn. (Fig. 7). In *Stipa comata* T. & R. (Fig. 9) we note a decided increase in size together with a certain degree of flexuousness which is such a prominent characteristic of the last two members of the series. Figure 9 is the fruit of the well-known porcupine-grass, *Stipa spartea* Trin. Every detail of the various parts has been perfected until one has a fruit which can literally bore its way into the sand as well as into the wool and skin of some unfortunate sheep. The neck of the awn is prominently twisted and very hygroscopic, the point is very sharp, and the hairs on the body of the fruit act retrorsely in their resistance to a backward action when the point is once started into the ground. The tail of the awn stands out at right angles to the arm and both wind and moisture cause a twisting motion. I have seen such fruits penetrating 2 or 3 inches into the sand and the awn circumscribing a perfect circle around the center. Commonly such an action does not take place since there is an abscission between the awn and the body of the lemma so that the awn is readily detached. It is also self-evident that in the same plot of prairie with the porcupine-grass other grasses succeed in being planted just as frequently, if not more so, even if they have no such wonderful equipment, in fact have no "special adaptation" whatever. *Stipa neomexicana* (Thurb.) Scribn. (Fig. 10) has added two interesting characteristics, namely flexuousness of the awn and hairs, and these characters as well as all the rest come to full fruition in the last species given, *Stipa pennata* L. (Fig. 11). This is truly a vegetable feather and can be used with as much effect as the highly prized aegret. The length of the awn is truly remarkable, often measuring over a foot. The structure is most beautiful and delicate. The other structures of the fruit are much like in the porcupine-grass. Now compare Fig. 1 with Fig. 11 and we see a most remarkable orthogenetic movement which has resulted in a structure which can certainly be of no use to the plant unless we follow the faith of the credulous selectionist and say that this remarkable device was especially evolved or created to attract monkeys and men by tempting them to use the fruits as ornaments and thus insuring distribution. But humor aside, the orthogenetic movement must have about expended itself. It does not seem possible to carry the progression much farther.

3. ORTHOGENETIC SERIES IN THE DEVELOPMENT OF THE HORN IN THE CORONA-HOODS OF MILKWEEDS.

(See Plate II).

The andrecium of the Asclepidaceæ is provided with a peculiar 5-lobed crown or corona. The corona-hoods are perfectly plain on the inner side, in the lower genera, like Acerates. Two species are represented in the drawings. Figure 1 represents the corona-hood of *Acerates viridiflora* (Raf.) Eat. It has two minute auricles at the sides near the base, thus really making the hood three-lobed. Figure 2 is the hood of *Acerates angustifolia* (Nutt.) Dec. The hood is three-toothed at the end, the acute middle tooth being merely a projection of the thickened midvein. In figure 3, which represents a corona-hood of *Asclepiadora viridis* (Walt.) Gr., a new structure is in evidence. The front side of the hood is cut off in order to expose the little crest or horn, since it does not project beyond the edges of the walls of the hood. This is a structure which has no antecedent. It is a new mutation and certainly has no utility to the apparatus in which it occurs. But a new process has been initiated in the system which may now progress until it evolves to a very prominent structural part of the milkweed flower. In the pleurisy-root, *Asclepias tuberosa* L. (Fig. 4), the horn has elongated greatly but is still nearly straight, while in *Asclepias sullivantii* Engelm. (Fig. 5) the horn is greatly enlarged and decidedly curved, the point projecting over the top of the stigma. A very extreme condition is attained in the horn of the hood of *Asclepias verticillata* L. (Fig. 6). The horn is about twice as long as the corona-hood and curves inward over the top of the stigma. Thus we see that in such a minute and useless structure as this little horn, the principle of progressive advancement and perfection is just as much in evidence as when the evolutionary change involves some important organ of the plant. All the milkweeds can be arranged in reference to the degree of evolution of this little corona horn. The whole series represents a succession of greater attainments until the limit is reached in the extreme species where the flower is decked out with this perfected device which has been supposed to aid in pollination but which plainly can have no such utility since Asclepiodora is really more successfully pollinated than the higher species of Asclepias. The whole series has survived and is successful

today; so it would be ridiculous to asumes an eliminative utilitarian cause to account for its origin and progression toward perfection.

4. A SIMPLE ORTHOGENETIC SERIES LEADING TO OVER-ADAPTATION.

(See Plate III).

We have all heard of how the giraffe got his long neck. The present series deals with the evolution of a "neck" at the upper end of an achene. There are a number of quite similar, independent evolutionary series in the Chicory family. The higher Compositales have very commonly developed a capillary pappus which takes the place of the vanished calyx. This pappus is, of course, epigynous in the composites while quite similar although hypogynous, capillary pappuses are developed in some of the Cyperaceæ. The ovulary of the composites is devoloped from the cortical layer of the flower bud and is not the ovulary of the carpels. The carpels are extremely vestigial and give rise only to the stigmas, style, and top of the ovulary. The neck at the top of the developing ovulary is thus a modified, cauline, cortical structure.

In *Sonchus oleraceus* L. (Fig. 1) the achene is normal, no lengthening factor being in evidence at the top. The pappus spreads out around the upper end and makes a very effective device for wind distribution. Our common species of sow-thistle are very successful weeds. When we take one step over to the genus Lactuca or lettuce a disturbance becomes evident as is shown in *Lactuca villosa* Jacq. (Fig. 2). A distinct elongation is present just below the pappus. Now this neck does not give the achene any special carrying advantages when compared with the Sonchus fruit because the neck is still too short and insignificant. Yet a mutative potentiality is indicated which, as the sequel will show, ends in a truly marvelous development. *Lactuca sagittifolia* Ell. (Fig. 3) has evolved a neck several times as long and is thus in the first stages of the production of an effective parachute. The neck is still considerably shorter than the body of the achene. In *Lactuca hirsuta* Muhl. (Fig. 4) the neck is about as long as the body of the achene, while in the highly evolved prickly lettuce, *Lactuca virosa* L. (Fig. 5) it is about twice as long. All the species of Lactuca arrange themselves in a close, orthogenetic series in respect to the neck

character. The prickly lettuce fruit is an ideal parachute and the seed is carried on downy wings of ease in the most exquisite fashion. But these plants have by no means reached the limit of progressive evolution either in respect to the structure under consideration or in various other important potentialities. Going a little father up the scale we meet a near relative of the lettuce, our common dandelion, *Leontodon taraxacum* L. (Fig. 6). Comparing the fruit of the dandelion with that of the prickly lettuce, we see that the latter is only a crude amateur in the production of an ideal parachute. The neck is now three to four times as long as the body of the achene which is ornamented by projecting prongs in a very pleasing manner. This ornamentation is already slightly in evidence in the achenes of Sonchus and Lactuca, for they are also comparatively highly evolved organisms and ornamentation is characteristic of high or extreme developments in very many lines of plants as well as animals.

We have all played at blowing the dandelion fruits from their disk and watched the parachutes sail away like a man gliding from a balloon in a man-made parachute. Now this perfected device is of no use to the dandelion. I am convinced that if it were no better than the one possessed by the sow-thistle my front lawn would still be well seeded from my next-door neighbor's crop or from the abundant dandelion community in a pasture several miles away to windward. In my back yard I have sow-thistles without the long neck on the achene and it keeps me busy at attempted eradication, just as the dandelion does in the front yard, and 20 years of effort have not succeeded in making my garden a desert in respect to Sonchus. In the dandelion we have a plain case of over-adaptation. The seed-carrying device is enormously more perfect than required for the safety and survival of the race. The dandelion has this structure not because it is of any life and death advantage to the individual but because it is one of the progressive stages in the orthogenetic development. Now one would think that nothing further would evolve. But evolution is commonly perfective in its main lines and when we study the dandelion fruit we see that a few perfective processes have not yet made their appearance. Following out another phylogenetic line of the Cichoriaceæ, which in itself would show the same interesting orthogenetic movement as the Lactuca series, we come to the last step which will be con-

sidered. In *Tragopogon porrifolius* L. (Fig. 7), the salsify of the garden, the neck is about as long as in the dandelion, being two to three times as long as the body of the achene. These long necks of the dandelion and salisfy apparently have about reached the limit. The rays of the parachute radiate out stiffly and from their sides long webby-plumose branches extend, interlocking with those from the next ray and thus weaving an ideal filmy canvass for the plane of the parachute. After the seed has been transported, the rays of the parachute are detached from the top of the neck by means of an abscission layer so the achene is not hindered in its descent into the earth. What more would you want? We have here the ideal of perfection. Now run through the series from Sonchus to Tragopogon and we see an orthogenetic evolutionary series moving persistently toward the extreme. And the entire evolutionary sequence was of no importance to the individual in its struggle against the adversities of its environment. Every one of the series would have been completely successful in its distributional and migratory requirements if the achene had never evolved a neck at all but had remained in the more simple state represented by Sonchus. Even a pappus would not be necessary. *Chrysanthemum leucanthemum* L. has no pappus whatever and no one would have the audacity to say that the oxeye daisy has any trouble in getting about in the world. You might just as well argue about the advantage or disadvantage of the green color to a green crystal, or about the advantage that a crystal may have in being 14-sided instead of 6-sided.

5. AN ORTHOGENETIC SERIES RESULTING IN A DECIDED FLATTENING OF THE VEGETATIVE SYSTEM.

(See Plate IV).

In Plate IV is given a series of diagrams to show the evolutionary progression from a radially three spiral system to a flat bilateral system. The lower Liliales, like other lower Monocotylæ, are plants with a three-spiral, radial symmetry and this condition is carried through to the lower, epigynous Iridales. Figure 1 represents a diagramatic transverse section of the stem and leaves of *Manfreda virginica* (L.) Salisb. belonging to the Amaryllidaceæ. The stem is cylindrical and the leaves are placed in the normal, radial positions. The reaction

system developing the centers of activity for the production of lateral organs dances a three-step. In other words, the property of correlation of dependent interaction extends but a third of the way around the stem bud. This as stated is the universal, primitive, monocotyl condition. In *Hymenocallis occidentalis* (Le C.) Kunth (Fig. 2) the reaction system is changed to a two-step, giving rise to a stem with two-ranked leaves. The centers of activity, developing the lateral appendages, are now 180° apart which shows that the correlation influence of the system has advanced considerably over the previous condition, so that the unitary reaction of the cells takes in a greater area or mass of cells than in the lower three-spiral system. This condition has evolved independently any number of times in the monocotyl series. It even appears occasionally as a temporary condition of bud-sporting, only to disappear again, as in the case of a Screw-palm (Pandanus) which suddenly changed from the normal three-spiral to a perfect two-ranked form and grew that way for five years when it again passed back suddenly to the three-spiral condition.

Figure 3 represents a projection of the stem and leaves of *Nemastylis acuta* (Bart.) Herb. of the Iridaceæ. Here we see the beginning of the flattening process. The stem is still cylindrical but the leaf blades show a peculiar vertical folding. *Iris germanica* L. (Fig. 4), the common iris or fleur-de-lis, shows a decided evolutionary progress in the flattening potentiality. The stem is considerably flattened; the leaf sheaths are keeled or equitant, and the leaf blades are completely flattened vertically. Figure 5 represents the condition developed in *Olsynium douglasii* (Dietr.) Bickn., a close relative of Sisyrinchium. The stem is much more flattened than in Iris. In *Sisyrinchium hastile* Bicken. (Fig. 6) the stem is flattened and has two prominent ridges on the two edges. The leaf sheaths and blades are becoming very narrow and thin. In *Sisyrinchium campestre* Bickn. (Fig. 7) the two ridges have expanded into two broad wings and in *Sisyrinchium graminoides* Bickn. (Fig. 8) the wing development has proceeded to the extreme extent. Thus the evolutionary movement has brought out a flat plant. The advance shows a movement step by step to the ultimate limit and has finally produced a plant that is ideal for the botanist to put into his plant press, when he is intent on preparing specimens for his *hortus siccus;* for which plants reduced to practically two dimensions are very appro-

priate. What more could you ask? The vegetative part of the plant is as flat as a pancake. Something has evolved in the plants that tends to throw the entire system to extreme flatness. Of what use is this to the plant? Why it is of no use. The plants which never passed one step from the primitive radial symmetry grow side by side with the blue eyed grass just as abundantly or even more so. If you must have a self-evident immediate use for this remarkable development, you will find it, as intimated above, by putting a specimen of this kind in your plant press. Your troubles in trying to reduce contrary plants to two dimensions will largely have vanished.

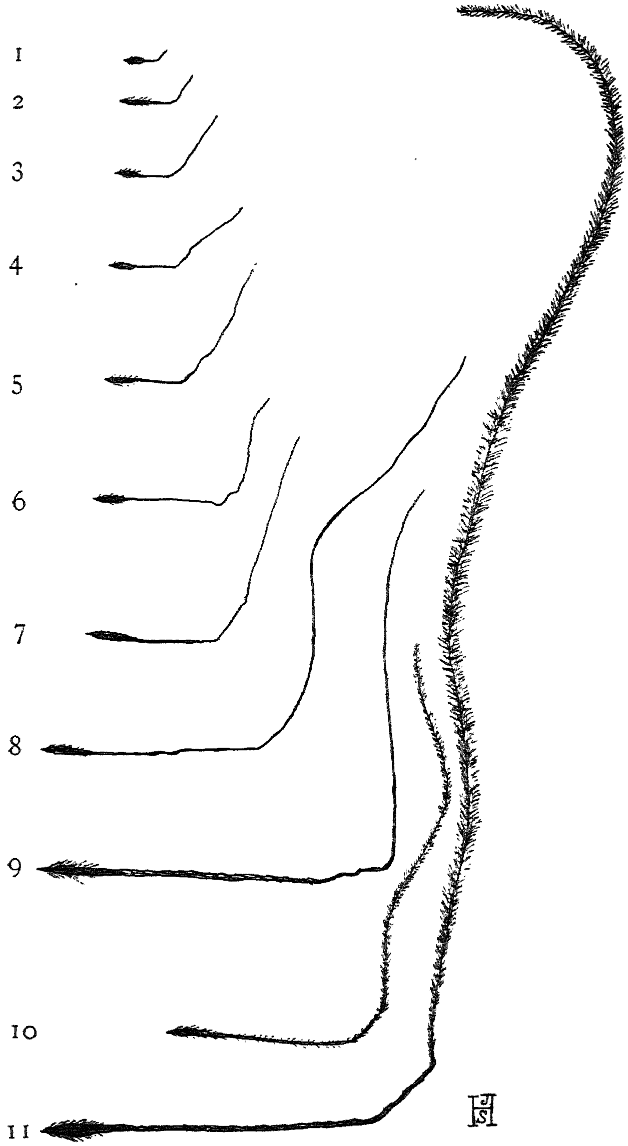
All of these studies again show that evolution does not proceed along utilitarian lines but that it is an intrinsic, kinetic process which is progressive, orthogenetic, and perfective in its results, the end product of the series often being a decided detriment to the convenience of the individual or, on the other hand, often a decided utility, developed enormously beyond the most extreme demands necessary for the successful perpetuation of the race. If we ask the question as to whether the plants which have taken the first steps in the progressive series will ever take any more and finally evolve to the ultimate possibility of the orthogenetic series, we have no evidence for an answer outside of the fragmentary answer of paleontology. In paleontology the evidence points mainly to the conclusion that there will be *no further change in the species as a whole* but it is possible that any individual in any of the species may take further steps in advance until the determinate limit of the series is attained. But such individuals are the first of new species and the old species continues to reproduce itself unchanged according to its hereditary constitution until it is eliminated through adverse conditions.

EXPLANATION OF PLATE I.

Progressive series in the evolution of the awn in Stipa.

Fig. 1. *Stipa macounii* Scribn.
Fig. 2. *S. scribneri* Vas.
Fig. 3. *S. viridula* Trin.
Fig. 4. *S. robusta* (Vas.) Scribn.
Fig. 5. *S. occidentalis* Thurb.
Fig. 6. *S. avenacea* L.
Fig. 7. *S. tweedyi* Scribn.
Fig. 8. *S. comata* T. & R.
Fig. 9. *S. spartea* Trin.
Fig. 10. *S. neomexicana* (Thurb.) Scribn.
Fig. 11. *S. pennata* L.

All reduced on the same scale to one-half natural size.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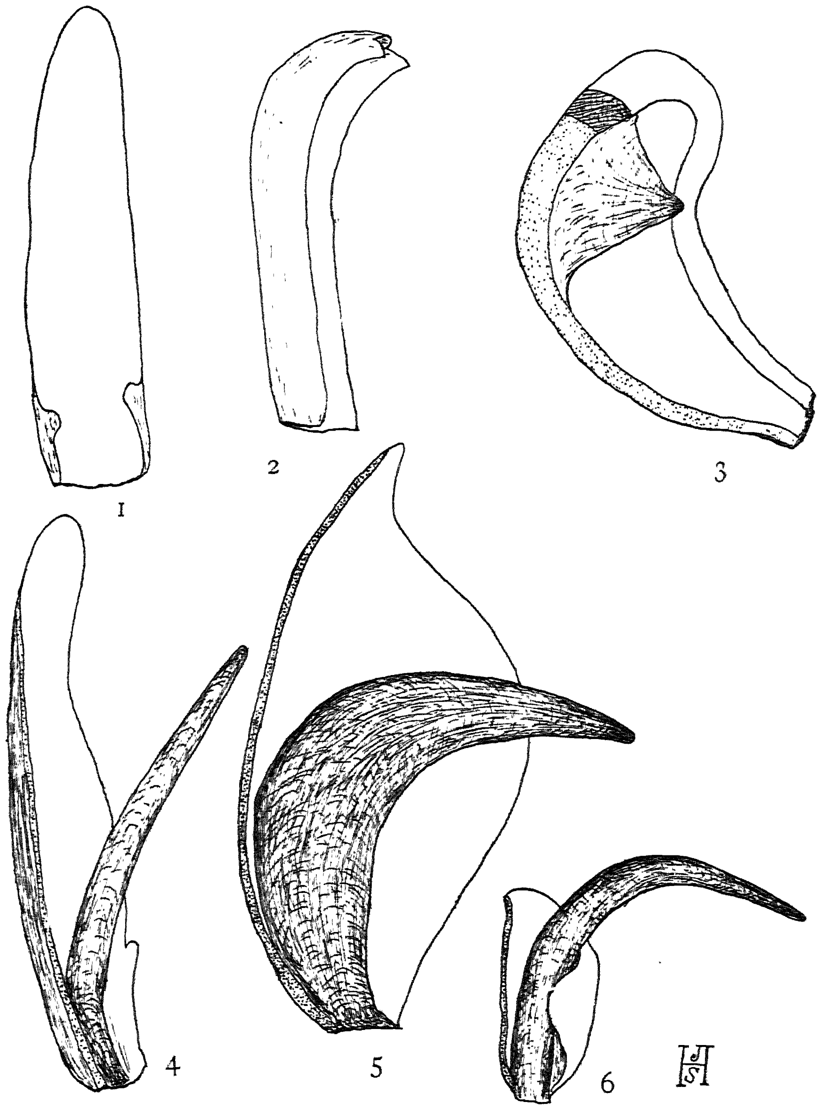
EXPLANATION OF PLATE II.

Evolution of the horn in the stamen appendage of species of milkweed.

Fig. 1. *Acerates viridiflora* (Raf.) Eat.
Fig. 2. *Acerates angustifolia* (Nutt.) Dec.
Fig. 3. *Asclepiadora viridis* (Walt.) Gr.
Fig. 4. *Asclepias tuberosa* L.
Fig. 5. *Asclepias sullivantii* Engelm.
Fig. 6. *Asclepias verticillata* L.

All magnified on the same scale about 6 diameters.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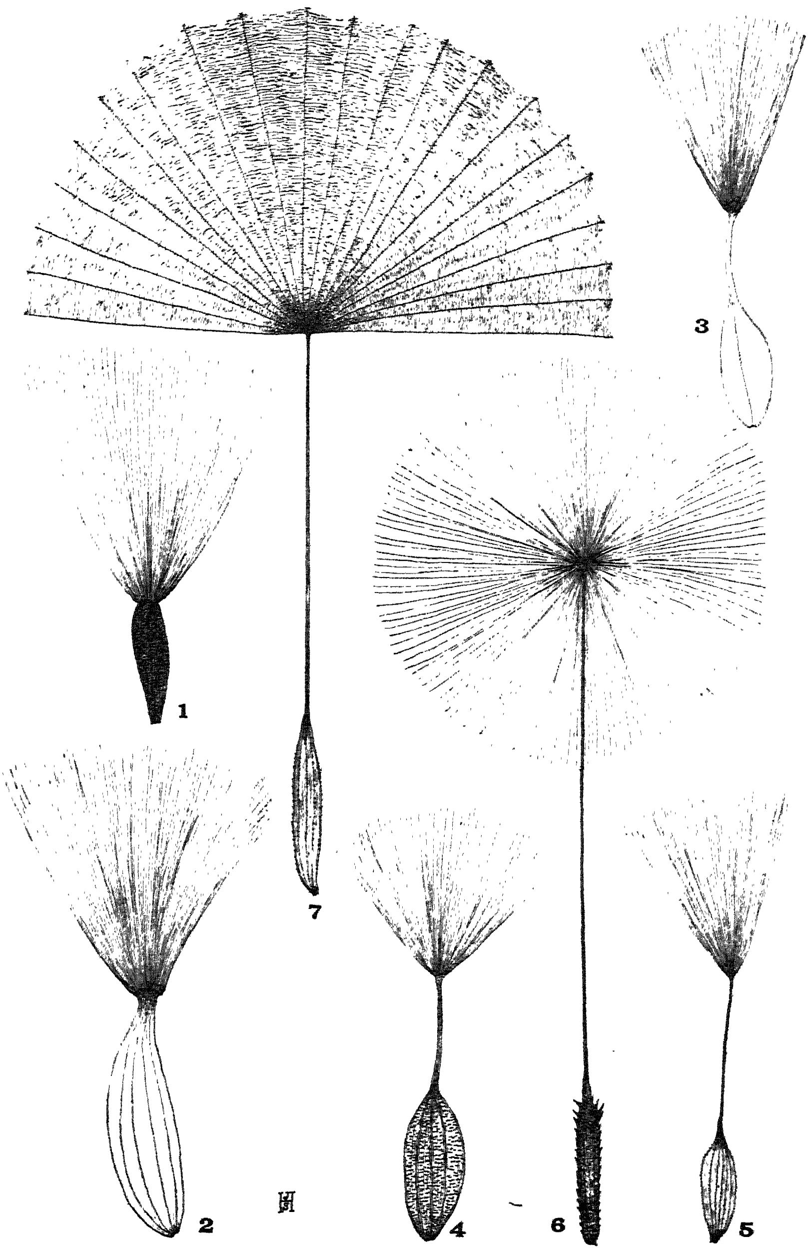
EXPLANATION OF PLATE III.

Orthogenetic series in the evolution of an elongated neck between the body of the achene and the pappus in the chicory family.

Fig. 1. *Sonchus oleraceus* L.
Fig. 2. *Lactuca villosa* Jacq.
Fig. 3. *L. sagittifolia* Ell.
Fig. 4. *L. hirsuta* Muhl.
Fig. 5. *L. virosa* L.
Fig. 6. *Leontodon taraxacum* L.
Fig. 7. *Tragopogon porrifolius* L.

All Figures magnified about 4 diameters except Fig. 7, which is magnified about 2 diameters.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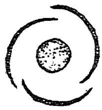
EXPLANATION OF PLATE IV.

An orthogenetic series from the Iridales showing a remarkable change from a radially three-spiral system to a flattened bilateral system. The figures are profile projections or cross-sections of the stem and leaves.

Fig. 1. *Manfreda virginica* (L.) Salisb. × ½.
Fig. 2. *Hymenocallis occidentalis* (Le C.) Kunth. × ½.
Fig. 3. *Nemastylis acuta* (Bart.) Herb. × 2½.
Fig. 4. *Iris germanica* L. × ½.
Fig. 5. *Olsynium douglasii* (Dietr.) Bickn. × 8.
Fig. 6. *Sisyrinchium hastile* Bickn. × 8.
Fig. 7. *S. campestre* Bickn. × 8.
Fig. 8. *S. graminoides* Bickn. × 8.



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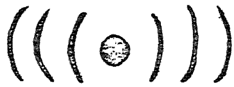

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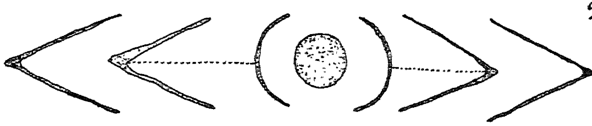

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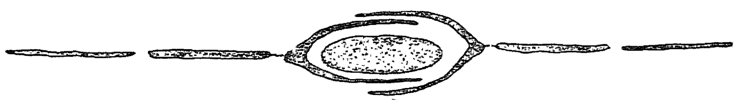

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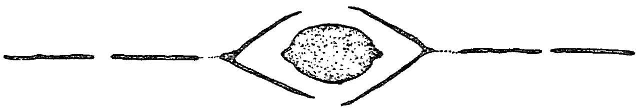

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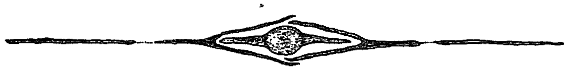

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BOOK NOTICE.

INSECTS, TICKS, MITES AND VENOMOUS ANIMALS OF MEDICAL AND VETERINARY IMPORTANCE. By W. S. PATTON AND ALWEN M. EVANS.

This work of 785 pages and numerous illustrations must be considered a successor to the very comprehensive and valuable *Text Book of Medical Entomology*, by Patton and Cragg, which is now out of print. The new book is adapted especially for class use and consists of exercises for twenty-eight lectures and laboratory periods with elaborate discussion of the material used for demonstration and reference to methods of preparation for the different species. It is especially full in descriptions and is admirably illustrated with figures of the morphological details concerned with the attacks of the species on their hosts and those used in identification. There is also considerable detail concerning life history and habits and some discussion of control measures. Other parts to be devoted to (2) "public health," (3) "tropical hygiene," and (4) "veterinary," are announced as in preparation. For students outside of the School of Tropical Medicine there may be a feeling of disappointment that no bibliographical references are given to works which are mentioned or which must naturally be consulted by a student of medical entomology. Possibly for the isolated student it would have been preferable to give some of this, even at the expense of less detail concerning specimens that are used as demonstrations under the direction of the authors. The book is available directly from the authors and the following announcement from Dr. Patton should be carefully noted:

"As it is the only practical book on the subject, the writer is strongly of the opinion that its price should be within the reach of all to whom it may be of use. Had it been published in the usual way its price would have been prohibitive to most medical officers and nearly all students of entomology. Under the circumstances it can only be obtained from the Entomological Department, Liverpool School of Tropical Medicine, and would-be purchasers will therefore only waste time by applying to booksellers, who will themselves have to obtain it from the above source. Any number of copies can be sent, and it will be just as easy, if not easier, to obtain it in this way as from a bookseller. The price, 20/-, includes packing and postage to any part of the world. All copies going to the United States will contain an invoice for Customs purposes. The duty will bring the price to about $5.00."

Apply with remittance (20/-) to Miss M. Brown, Department Entomology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool, England.

The book is a fine example of technical work and beautifully printed. It will certainly be warmly welcomed by students of medical entomology.

HERBERT OSBORN.

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A POPULAR KEY TO THE DISTINCTIVE GROUPS OF THE LARGER FUNGI.*

W. G. STOVER.

In the writer's courses in Mycology the student is encouraged, so far as it is possible, to determine the names of a number of fungi in each group studied. This procedure has been very unsatisfactory with any of the existing keys. There are, of course, keys and other methods of determining the genera and species of a number of the groups, such as Kauffman's "The Agaricaceæ of Michigan," Overholts' "The Polyporaceæ of the middle-western United States," Coker's "Clavarias of the United States and Canada," and others. There is, however, no easy method of determining the group to which a specimen may belong.

A key to the principal distinctive groups was therefore prepared on the basis of characters which can be readily seen in mature specimens as collected and in terms within the comprehension of the amateur in the study of the fungi. This key has been tested by use with students in the laboratory for three or four years and extensively revised several times as a result.

Although originally prepared for use by classes in Mycology, this key will probably prove helpful to others. There are doubtless many persons who desire to know at least the general group to which the fungi observed during rambles through the woods and fields may belong. This known, it is relatively easy to determine the genus and species, provided the necessary literature is available.

Most of the common fungi of appreciable size can be readily traced, by means of this key, to the proper group. Both the common and scientific names of each group are given, the common name in parenthesis. An effort has been made to

*Papers from the Department of Botany, The Ohio State University, No. 257.

segregate the distinctive kinds of fungi and, in consequence, the groups listed are of different ranks, including classes, subclasses, orders and families.

The use of microscopic characters is avoided so far as possible. Unfortunately certain fungi, even of relatively large size, can not be distinguished from certain others without study under the microscope. Microscopic characters are frequently added, usually at the end of the paragraph, as a further aid in determination when a microscope is available.

In general the key is built upon the dichotomous plan, that is, the reader, at each step, is given the choice of two sets of opposing or contrasting characters. For the sake of conserving space, however, this plan is not followed throughout, in several places three or more sets of contrasting characters being listed. In each case the paragraphs containing these sets of characters are all given the same number. In tracing a specimen through the key, therefore, all paragraphs bearing the same number should be read and compared with the specimen before a decision is reached.

Key to the Groups of the Larger Fungi.

1. Macroscopic fungi; characterized by the development of fruiting bodies or spore masses whose nature and general structure can be determined without a microscope.. 2
1. Microscopic fungi; no fruiting bodies of conspicuous size developed (not treated in this key).
    2. Fungus seen as a mass of threads or filaments (which are mostly without cross-walls).. 3
    2. Fungus not as above.. 4
3. Fungi aerial; at first usually white, later tawny to brown or black, usually with many minute brown or black sporangia (Filamentous Black Molds)..*Mucorales*
3. Fungi aquatic, always white (Water Molds)..................*Saprolegniales*
    4. Fruiting structures dusty, powdery or cottony at maturity, with or without an outer membrane.................................... 5
    4. Fruiting bodies of compact structure, not dusty or cottony........... 8
5. Fungi parasitic on green plants.. 6
5. Fungi saprophytic, growing on the ground or on dead organic material..... 7
    6. Spore masses or fungous growth white to smoky or violaceous; cottony (with conidiophores) or dusty (at first blister-like). (Downy Mildews and White Blisters).................*Peronosporales*
    6. Spore masses black or dark brown; floral organs attacked mostly, sometimes the leaves or stems; spores not stalked (Smuts), *Ustilaginales*
    6. Spore masses yellowish to bright red or reddish-brown, or if black or dark brown, the spores are stalked; leaves and stems mainly attacked (Rusts)...*Uredinales*
7. Fruiting bodies aerial, always arising from a mycelium; usually more than one-fourth inch in diameter; usually globose, but sometimes with a thick base or rather slender stalk; stalk never hair-like; all species with a surrounding membrane persistent until maturity; sometimes splitting radially and spreading out in starlike segments; threads (capillitium) without distinct surface markings and never forming a network (Puffballs, Earth-Stars)........................*Gasteromycetæ*

7. Fruiting bodies (spore masses) aerial, arising from a mycelium, without a membrane, usually forming a flat layer, or if in tufts usually less than one-eighth inch in diameter (Blue and green molds)........*Aspergillaceæ*
7. Fruiting bodies subterranean, arising from a mycelium, with a thick firm membrane (False Truffles)........................*Elaphomycetaceæ*
7. Fruiting bodies aerial, never arising from a mycelium; usually less than one-fourth inch in diameter and very numerous; sessile or with a hair-like stalk; surrounding membrane present or absent; capillitium often with spirals, rings, pegs or other markings, sometimes forming a network; if more than one-fourth inch across, fruiting body is either flat or globose; if globose the capillitium has distinct surface markings (Slime Molds)...*Myxomycetæ*
   8. Plants grayish-green (some are yellow, olivaceous, brown or black); either circular and leaflike, or erect or pendulous and branched (some form a thin flat crust); papery, leathery or gelatinous in texture; growing on the bark of trees, on stumps, old timbers, rocks, or on the ground; (the plant structure as seen under the microscope consists of fungous elements and green or blue-green algal cells)..(*Lichens*)
   8. Plants not grayish-green; fruiting bodies woody, corky or tough-leathery at maturity.. **9**
   8. Plants not grayish-green; fruiting bodies fleshy or jelly-like when fresh or wet, sometimes rather tough but not leathery..............**14**
9. Fruiting body rather flat, disklike or irregular in outline, usually black, splitting in more or less radiating lines at maturity (Tar Spot Fungi), *Phacidiales*
9. Fruiting bodies cup- or vase-shaped......................................**10**
9. Fruiting bodies not as above...**11**
   10. Fruiting bodies containing egg-like bodies (Birds' Nest Fungi), *Nidulariales*
   10. No egg-like bodies present; inner surface of fruiting bodies with microscopic sac-like asci containing spores (Cup Fungi)....*Pezizales*
11. Fruiting body consisting of a minute to rather large, hard or woody structure (stroma), sessile or stalked, with minute dots or pimples (perithecia within); or consisting of single or aggregated more or less spherical perithecia; perithecia containing spores in sac-like asci (Sphere Fungi)......................................*Pyrenomycetæ*
11. Fruiting body without minute pimples, perithecia and asci; often a stalked cap, or attached to the substratum by the side (shelving), or more or less flat and attached by all or most of the upper surface (resupinate)....**12**
   12. Lower surface of cap or fruiting body with teeth, pores, pits or gills (leaflike plates or veinlike ridges).............................**13**
   12. Lower surface of cap or fruiting body even; without teeth, pores or gills; sometimes erect and branched (Smooth Fungi)..*Thelephoraceæ*
13. With spines or teeth, usually on the lower surface of a cap or fruiting body (Tooth or Spine Fungi).................................*Hydnaceæ*
13. With shallow pits, or roundish, angular or elongated tubes or pores, sometimes with thin plates, either labyrinthiform or concentrically arranged on lower surface of cap or fruiting body; often on wood (Woody Pore Fungi)...*Polyporaceæ*
13. With thin or vein-like gills radiating from the stalk or point of attachment on lower surface of cap or fruiting body (Gill Fungi).........*Agaricaceæ*
   14. Under surface of cap or fruiting body provided with thin or vein-like radiating plates or gills (Gill Fungi)...................*Agaricaceæ*
   14. Under surface of cap or fruiting body provided with pores or tubes; usually terrestrial (Fleshy Pore Fungi)..................*Boletaceæ*
   14. Fruiting body fleshy but not gelatinous, consisting of or bearing numerous teeth or spines (Tooth or Spine Fungi)..........*Hydnaceæ*
   14. Fruiting body of gelatinous or jelly-like consistency, shelflike, bearing numerous short teeth or spines on the lower surface (Jelly Fungi)...............................(*Tremellodon*) *Protobasideæ*
   14. Fruiting body without gills, teeth or pores..........................**15**

15. Plants usually with a strong disagreeable odor when fresh; fruiting body with a distinct sheathing cup at the base, usually stalked, but sometimes a more or less globose lattice-work, or rarely reduced to an egg-like structure which ruptures irregularly at the apex; spore mass greenish, at first firm, later deliquescing, usually borne at the apex of the stalk or on a special cap-like, lattice-like or branched, receptacle; fruiting body one to six inches long (Stinkhorns)................*Phallales*
15. Plants usually without marked odor; fruiting body stalked or sessile without sheathing cup at base; spore mass not liquified at maturity......16
    16. Fruiting body disk-, saucer-, cup-, funnel-, or vase-shaped............17
    16. Fruiting body not as above...18
17. Plants always parasitic; cup-like bodies yellow to orange, minute, usually in crowded clusters; spores borne in chains within the cups, usually angular (Rusts)..*Uredinales*
17. Plants saprophytic, growing on wood, brown, jelly-like (Jew's ear), *Protobasideæ*
17. Plants usually saprophytic, rarely parasitic in this stage; cup-like bodies variously colored; minute to large; spores borne in sac-like asci lining the inner surface of the cup, not angular, (Cup Fungi)............*Pezizales*
17. Plants saprophytic; cups not in crowded clusters; individual cups usually 1 cm. or more across; (spores borne on the exterior of the cup, not in chains nor in asci) (Smooth Fungi).........................*Thelephoraceæ*
    18. Fruiting body gelatinous or jelly-like..............................19
    18. Fruiting body fleshy, not jelly-like................................20
19. Plants parasitic; gelatinous fruit body composed mainly of two-celled spores and their stalks (Rusts)..............................*Uredinales*
19. Plants saprophytic, growing on soil; fruiting body green, often slimy, with distinct stalk and cap or head; head covered with a layer of sac-like asci with spores (Leotia)................................*Helvellales*
19. Plants saprophytic, growing on wood; fruiting body without distinct stalk or head; spores not in asci (Jelly Fungi)................*Protobasideæ*
    20. Fruiting body subterranean, globoid..............................21
    20. Fruiting body aerial; globoid or with thickened base or with slender stalk; compact within when young, later becoming more or less dusty, often with cottony threads (capillitium); with an outer thin or thick covering (peridium), the outer layer of which sometimes splits radially and spreads out in star-like segments (Puff-balls, Earth Stars)..................................*Gasteromycetæ*
    20. Fruiting bodies aerial; usually erect, but sometimes without a stalk, not globose..22
21. Spores borne in persistent sacs (asci), asci with 1 to 4 rough spores (Truffles)..*Tuberales*
21. Asci soon disappearing leaving the spores in a more or less dusty mass, (False Truffles)......................................*Elaphomycetaceæ*
    22. Fruiting body usually bright colored, but sometimes brown or blackish in age, with or without a head; partly covered with minute dots or pimples (perithecia, asci and ascospores within), (Colored Sphere Fungi)...............................*Hypocreales*
    22. Fruiting body without pimples; stalk-like, tongue-like, spatulate, capitate or pileate, unbranched; upper portion covered with a layer of asci containing spores (Morels, Earth Tongues)..*Helvellales*
    22. Fruiting body without pimples and without asci; simple or branched, round in cross section; white, yellow, light brown or some light shade of red or purple (Coral Fungi).....................*Clavariaceæ*
    22. Fruiting body without pimples and without asci; simple or branched, usually arising in a cluster; flattened in cross section (Smooth Fungi)..*Thelephoraceæ*

THE INTERNAL ANATOMY OF THE MYDAS FLY.*

LYDIA A. JAHN

INTRODUCTION.

The following work is a report on the internal anatomy of the Mydas fly, *Mydas clavatus* Drury. In a survey of the literature dealing with certain insect groups it was found that nothing is known concerning the internal anatomy of the primitive flies of the Family *Mydaidæ*. Indeed, very little information of any kind is found which discloses the habits or life history of this large Dipteron. It was thought that a knowledge of the internal anatomy might indirectly reveal some of the life habits. A few carefully killed and fixed specimens of *Mydas clavatus* being available, a detailed dissection and microscopical examination was made. The Mydas flies are not common in Ohio, only two species have been reported from the state. The species used is a large, dusky, brown fly in which the dorsal sclerite of the second abdominal segment is marked by an orange band, and the antennæ are clavate and black. It is occasionally taken along Lake Erie on the sandy beach at Cedar Point, where the specimens used in this study were collected. Usually individuals of the group are found on dry, decaying logs or tree stumps. Owing to the scarcity of material it was necessary to use the same specimens for gross dissection and for the microscopical examination, consequently extreme care was taken during all manipulations.

I wish to express my thanks to Dr. C. H. Kennedy under whose supervision this investigation was carried on and also to Prof. J. S. Hine for the identification of specimens.

METHODS.

Only three specimens were available, two females and a male. These flies were killed and fixed in Kahle's Fixative and then preserved in 70% alcohol.

Gross Dissection. It was slightly unwieldy to work with the legs and wings attached therefore these were first clipped from

* Contribution No. 98 from the Department of Zoology and Entomology, Ohio State University.

the body. The insect was then pinned out in a dissecting pan and covered with alcohol. All dissections were made under 70% alcohol with the aid of the binocular microscope. The alcohol was frequently renewed in order to insure preservation during gross dissection. The entire dorsal body wall was first carefully removed in minute particles after which the muscles of the thorax were taken out, exposing the alimentary canal for study. The nervous system and the reproductive systems were studied after the alimentary canal had been removed. No histological work was attempted with these systems, but drawings of the gross structures were made free hand while using the binocular microscope.

Microscopical Technique. The parts of the alimentary canal were cut into convenient lengths, run through the alcohols, cleared and imbedded in paraffin. All sections were cut seven microns thick and stained with a double stain of Delafield's haemotoxylin and eosin. The drawings were made with the aid of a camera lucida.

The Anatomy of the Digestive System.

The alimentary canal is a comparatively short tube and suggests the carnivorous habit. In the higher Diptera the digestive system may reach a length almost twice that of the insect itself, and appears as a convoluted mass filling the abdomen. In the Mydas fly, however, it extends as a straight tube throughout its length with the exception of several convolutions in the hind gut where it loops back upon itself twice. Plate I, Figure II.

In insects the fore gut is an invagination of the ectoderm at the anterior end and is called the stomodaeum. The hind gut is formed in a similar fashion and is a posterior ectodermal invagination called the proctodaeum. Connecting these two regions is the mid gut which is derived from endodermal tissue. In correlation with the external epithelium the epithelial lining of the fore and hind guts secretes chitin which is found lining these regions as a definite membrane. The parts of the alimentary canal will be discussed in the following order:

- A. Mouthparts.
- B. Fore Gut.
  1. Pharynx.
  2. Oesophagus.
  3. Oesophageal Valve.
  4. Salivary Bulb.
  5. Salivary Duct.
  6. Salivary Glands.
  7. Crop.
- C. Mid Gut.
  1. Gastric caeca.
  2. Stomach (proper).
  3. Pyloric Valve.
- D. Hind Gut.
  1. Malpighian Tubules.
  2. Intestine.
     a. Rectum.

I. GROSS STRUCTURES.

A. Mouthparts.

The mouthparts of the Mydas fly have been worked out and figured by Peterson (1916), and present a type of structure similar to that in the robber flies and horse flies, but distinctly less specialized. This is another evidence of the predaceous method in acquiring food, although there is no record which shows that the adult Mydas fly has ever been observed actually attacking another animal.

B. Fore Gut.

The *pharynx* is the anterior end of the alimentary canal and lies just posterior to the mouth. Food is conveyed by means of the pharynx to the oesophagus; in this fly there is no essential difference between the structure of the pharynx and the oesophagus.

The *oesophagus* begins posterior to the pharynx and extends to the anterior end of the mid gut. Its diameter gradually increases in size until the posterior end is twice as large as the anterior. The oesophagus gives the appearance of an opaque, chalky white tube.

The *crop* is a dilatation of the ventral wall of the oesophagus. This is an out-pocketing which is so pronounced in the Mydas fly that the crop itself lies in the abdomen and is connected with the oesophagus by means of a long slender tube. The tube lies just beneath the stomach, branching off at the posterior end of the oesophagus and continuing until it reaches the second abdominal segment. The crop functions as a food reservoir.

The *oesophageal valve* represents the posterior limit of the fore intestine and is really a prolongation of the fore gut into the mid gut.

The *salivary glands.*—"The salivary duct extends through the hypopharynx to its distal end." (Peterson). Here the tube enlarges to form the salivary bulb, then narrows again and eventually passes upward and back through the head and neck. Before it leaves the head it divides forming two ducts which extend through the neck to the thorax and lie, one on either side of the oesophagus close to the anterior end of the thoracic cavity as thickened convoluted tubes. These posterior thickenings are the glands proper. Secretions pass from the glands to the ducts and are then transferred to the hypopharynx. There they are mixed with the food and are probably the first agents in digestion.

C. Mid Gut (Stomach).

The *gastric caeca* are two pouches which represent out-pocketings in the anterior end of the *stomach* and lie at right angles to the remainder of the alimentary canal. They occupy the entire anterior end of the thoracic cavity. Numerous projections on the surface of the caeca appear as evaginations which increase the secreting surface. Similar secreting sacs are also found posterior to the caeca but not as extensively, and they do not occur on the posterior half of the stomach. The stomach extends to the pyloric valve. It has a uniform diameter for two-thirds of its length and then gradually increases in size.

The *pyloric valve* is the posterior limit of the mid gut. It is the point of insertion of the malpighian tubules.

D. Hind Gut (Intestine).

The *malpighian tubules* define the anterior limit of the hind gut. There are four tubes, two branching from the dorsal surface and two branching from the ventral surface. These twine in and out among the digestive organs and other body structures. They are excretory in function, extracting urinary wastes from the body.

The *intestine* includes all the structures of the hind gut. The ileum is the smaller anterior end of the hind gut and the colon the larger posterior part. In the Mydas fly there is no distinguishable difference in the size or structure of these regions.

The *rectum* represents an abrupt enlargement of the posterior end of the hind gut. The surface of the rectum is spotted with the bases of rectal glands or papillæ which project into the rectal lumen. These are confined to three general rows and are about thirty-three in number. No definite function is known for these glands.

II. HISTOLOGICAL STRUCTURES.

A. Fore Gut.

The following tissues can be demonstrated in a histological examination: (1) a chitinous intima, (2) epidermal layer, (3) longitudinal muscle layer, (4) circular muscle layer. The innermost layer is an *intima of chitin* which is secreted by the epidermal cells. It is a non-cellular membrane, and forms a thick layer of very flexible chitin. The next layer is composed of flattened *epithelial cells.* In most places it was possible to distinguish cell walls quite easily but in others the entire layer resembled a syncytium. Immediately outside the epithelium is a layer of *longitudinal muscle fibers.* These are arranged in the form of a dense network several fibers in thickness. The outermost layer of the oesophagus is composed of *circular muscle fibers* which occur in scattered bundles. See Figures I and II, Plate II.

The *salivary glands* are part of the fore gut and are therefore ectodermal in origin. They are composed of a single layer of columnar cells which contain large nuclei. There is an intima of chitin present which lines these glands. Figure IV, Plate II shows the salivary gland as it appears in cross-section.

The *oesophageal valve* is the division between the fore and mid gut and is formed by an invagination of the fore gut into the mid gut. Several kinds of epithelial cells are found in the valve making it impossible to determine just which cells are derived from the fore gut and which from the mid gut. In the oesophagus are found the flattened epithelial cells described above. At the entrance to the valve the form of the cells changes abruptly and a disc composed of columnar epithelium is formed. Immediately posterior to the disc the cells decrease in size and number and their long axis becomes parallel to the position of the digestive tract. The tube is very narrow here. Figure I, Plate II shows this narrow passage filled with chitin and the tips of underlying cells which have extended inward so that they almost close the lumen. At the posterior margin of the valve the epithelial cells are considerably elongated and very numerous. These cells form a heavy collar which makes a thick wall at the anterior end of the stomach.

The ring of cells at the anterior and the collar of cells at the posterior end give the valve the appearance of an ambidisc. The region between the two discs is heavily supplied with circular muscles, which possess the ability to shut off the passage to the stomach and thus afford an opportunity for food to pass to the crop. The epithelial cells in the mid gut just posterior to the oesophageal valve are thicker and not as long as those found in the posterior disc. Their inner surfaces are covered by a peritrophic membrane which arises at the anterior end of the mid gut and appears as though it were secreted by the cells of the digestive epithelium.

The tube leading to the *crop* begins immediately anterior to the first disc of cells in the valve. This tube is lined with an intima of chitin, then a layer of squat epithelial cells. The outside is provided with a heavy layer of circular muscles.

In Figure I, Plate II the oesophageal valve and the tube leading to the crop are shown in longitudinal section.

B. Mid Gut.

A histological examination of the mid gut reveals the following tissues: (1) peritrophic membrane, (2) enteric epithelium, (3) circular muscle layer, (4) longitudinal muscle layer. The mid gut shows a non-specialized type of structure which is common to lower insects generally. The *peritrophic membrane* appears to be secreted by the gastric epithelium. It appears as a distinct non-cellular membrane which functions as a protection to the epithelium. It covers the cells and shows up very distinctly in cross section. Figure III, Plate II shows how closely the membrane lies to the epithelial layer. The next layer is that of the actively functioning endodermal *epithelial cells*. There is no specialized type of nidi or cell nests. The cells which are destroyed in holocrine secretion are replaced by others which are narrow, elongate cells at the bases of the active, secreting cells, and are interspersed among them. They are not confined to any definite region but occur singly, scattered among the functioning cells. The digestive epithelium is composed of columnar cells which are grouped together forming projections into the lumen of the alimentary canal. The cells are narrow at their bases and flare at their tips, due perhaps to the crowded condition of the developing cells. The flaring outer ends of the cells form irregular projecting folds. At the very apex of these cells are numerous granules which resemble the basal bodies of cilia, and form a distinct line around the outer edge of the cells when viewed in cross section.

Between the cells of the digestive layer and the muscles layer is an area filled with numerous branching filaments which stain red with eosin. The finger-like extensions of this layer are projected between the cells of the epithelium. The branched condition and the extension of the filaments between the cells has led the writer to believe that they are tracheoles whose tips are found among the cells.

The bundles of *circular muscle* lie outside the above layer and form a closely united ring around the stomach wall. The *longitudinal muscle* fibers are found in groups just outside the circular layer. The muscles are not closely united and form loose bundles usually consisting of three or five fibers.

C. Hind Gut.

The tissues of the hind gut are arranged in the following manner: (1) an inner intima of chitin, (2) an epithelial layer, (3) a circular muscle layer, (4) a longitudinal muscle layer and (5) around the malpighian tubule there is a peritoneal membrane.

The *plyoric valve* represents the boundary between the mid and hind guts. The epithelial cells of the mid gut are greatly elongated and their tips are directed posteriorly, projecting, as a ring into the cavity of the hind gut. The malpighian tubules are inserted between the mid and hind guts. At their origin the tubules are formed of slender, elongate cells which are crowded very closely together. These cells do not possess the striated border common to the cells in the malpighian tubule. The cells gradually increase in size going away from the basal end of the tubule, and contain larger nuclei. Figure III, Plate III shows a longitudinal section through the pyloric valve.

In the region behind the pyloric valve and just anterior to the rectum is an area in which the intima forms a thin layer that appears as a heavy line around the inner edges of the epithelial cells. The latter, as found in this region of the intestine, are almost square in shape, and appear like columnar cells. The muscle layers are not highly developed.

In the *malpighian tubules* the epithelial cells are very large, and their inner ends are lined with a striated border which appears as if composed of cilia. At the bases of the striations granules are found which show up very distinctly. Whether or not these are true cilia is unknown. Figures I and II, Plate III show sections through the malpighian tubules.

In the *rectum* the intima of chitin is not as thick as that in the fore gut but is considerably thicker than the same layer elsewhere in the intestine. It extends as a wavy membrane over the epithelial cells. Figure V, Plate III shows the arrangement of the tissue in the rectum. The epithelium is composed of flattened cells much like those in the fore gut. The circular muscle layer is developed to a high degree. The bundles appear to be piled up in heaps, giving the inside a folded appearance. The longitudinal muscle layer contains larger fibers than have been encountered anywhere else in the gut.

The *rectal papillæ* project finger-like into the lumen of the intestine. There are approximately thirty-three papillæ whose external openings dot the surface of the organ, and are confined to three general rows. In the higher Diptera the number of papillæ is much smaller. Each papilla is composed of large epithelial cells which probably are pushed inward due to the proliferation of cells from an active, growing region at the tip. The cells here are smaller than at the base of the papilla, where large irregular cells occur. The cells are arranged in a double row, each row a single cell in thickness. Between these two rows of cells numerous tracheoles are found. There is a smooth layer of chitin around the papilla without spines or other structures common to more specialized forms of papillæ. The rectal papilla of the Mydas fly shows this structure in its primitive form.

THE NERVOUS SYSTEM.

I. Brain.
   a. Protocerebrum.
      Protocerebral lobes.
      Optic lobes.
   b. Deutocerebrum.
      Antennal Nerves.
   c. Tritocerebrum.
   d. Suboesophageal ganglion.

II. Ventral Nerve Cord.
   a. Ganglia.
   b. Lateral Nerves.

A superficial examination of the nervous system of the Mydas fly reveals the following external structures. The brain or cephalic ganglia lie in a fused mass in the head. A double row of united ganglia lies on the ventral floor of the thoracic and abdominal cavities.

The most obvious structure and one which includes the greatest part of the brain is called the *protocerebrum*. It is composed of two distinct parts, the protocerebral lobes and the optic lobes. The protocerebral lobes are fused along the median line and form a bilobed mass, which indicates its original derivation from a pair of ganglia in the optic segment. This nerve mass enervates the compound eyes and the ocelli. At the junction of the protocerebral lobes three nerves are given off. Two of these unite at their distal ends to form the saddle shaped structure observed in side view in Figure VIII, Plate I. This structure is pigmented on its outer border over the area that lies beneath the external ocelli. The third nerve enlarges at its distal end to form a bulb-like organ which is also pigmented on its outer surface and lies just beneath the median ocellus. The optic stalk is continuous with the protocerebrum and enlarges to form the huge optic lobes. These lobes form most of the brain and are developed to the same extent as the compound eye.

The deutocerebrum lies a little anterior and ventral to the protocerebrum. The antennal nerves are given off from this portion of the brain.

The third part of the brain or the tritocerebrum lies posterior and ventral to the deutocerebrum and is composed of two united lobes. The mouthparts are enervated from nerves which arise from this part of the brain and in the *sub-oesophageal ganglion* which is indistinguishable from the tritocerebrum.

The nerve cord lies in a double row of united ganglia along the ventral wall of the thorax and abdomen. Only two pairs of ganglia are found in the thorax showing that there is a concentration of ganglia in this region. From these ganglia nerves are given off which supply the wings and legs. From the ganglia in the abdomen pairs of lateral nerves arise. There is some fusion of ganglia in the posterior of the abdomen since three pairs of nerves arise here instead of the usual one pair. Centralization of ganglia has progressed to some extent in both the thorax and abdomen but not appreciably.

The outstanding features of the nervous system in the Mydas fly are the marked development of the optic lobes and the cephalization in the thoracic and abdominal ganglia. This condition shows the first stages in cephalization which has proceeded to such a marked degree in the muscid flies.

THE MALE REPRODUCTIVE ORGANS.

I. Testes.
II. Vas deferens.
III. Ejaculatory sac.
IV. Ejaculatory duct.

The *testes* are considerably smaller than the ovaries. A pair of them lies in the third abdominal segment, ventral to and on each side of the alimentary canal. The testes are spherical bodies which have a diameter slightly greater than the vas deferens.

The *vas deferens* consists of a pair of tubes which extend from the testes to the posterior. They are white and coil several times before they finally unite to form a single tube. In the posterior of the abdomen these tubes have formed such a convoluted mass that in the specimen used it was impossible to determine the exact place at which the tubes united. In Figure V, Plate I the dotted lines indicate the joining of the two tubes to form one as it might occur. After the tubes of the vas deferens have joined the diameter of the resulting tube remains the same as that of the other tubes until it reaches its posterior end. Here it narrows gradually and finally merges with the ejaculatory duct. The latter begins immediately back of the entrance to the ejaculatory sac.

The *ejaculatory sac* is a blind, pouch-like tube which branches to the right of the vas deferens. Its diameter is the same as that of the vas deferens where it branches off. Gradually, however, the tube enlarges and forms a large sac.

The *ejaculatory duct.*—The remainder of the system posterior to the branching of the ejaculatory sac is called the ejaculatory duct. It has a very large diameter as it nears its end.

THE FEMALE REPRODUCTIVE ORGANS.

I. Ovaries.
 a. Ovarioles.
II. Oviducts.
III. Vagina.
IV. Seminal receptacles.
V. Colleteria.

The female Mydas fly in which the reproductive organs were observed had apparently been fertilized and engaged in egg laying. The abdomen was distended by the numerous eggs which filled the body cavity. Some of these were already equipped with chitinous shells. Figure IV, Plate I shows a drawing made while the eggs were still in place in the abdomen.

Ovaries.—The ovaries are composed of numerous sac-like structures called ovarioles. These are joined at their bases to form a duct which eventually unites with one of the oviducts. It was impossible to trace the connections between the ovarioles in this specimen. The ovarioles and their contents completely filled the abdomen and were firmly pressed together, distorting some of the other organs. The *ovarioles* are tubes in which the eggs are formed. Each ovariole appears to end freely in the body cavity without any attachment to the body wall or other internal structure. The eggs lie as chains in an ovariole, one behind the other. The oldest eggs lie nearest the union with the oviduct. An ovariole consists of several distinct parts. The distal end is termed the terminal filament. A thin peritoneal layer covers the outside of an

ovariole and is continuous with the oviduct. Within this lie the developing ova. The type of egg here found clearly shows that *Mydas clavatus* does not deposit fully formed larvæ but the egg must undergo a period of incubation after it is laid.

The *oviducts* are thin walled tubes which lead from the ovaries to the vagina. They extend posteriorly and form the vagina after they unite.

The *vagina* extends from the union of the oviducts to the outside.

There are three *seminal receptacles* which enter the vagina at the point where it opens to the outside. Each receptacle is a blind, pouch-like tube which has an inner chitinous lining. This is visible through the external layers and gives a faint yellow tinge to the tubes at their tips. As the eggs pass through the vagina sperms are transferred from the seminal receptacles and enter the eggs through the micropyle.

The *colleteria* are two long white tubes which enter the vagina just posterior to the seminal receptacles. Figure III, Plate I shows these pushed back out of the abdominal cavity. They lie at either side of the vagina in the normal fly. These glands are functional in that they produce a sticky substance. The substance produced in the Mydas fly probably serves to attach the eggs to some object when oviposited.

The *egg* is one millimeter in diameter. At the end which lies toward the anterior of the mother is a faint white spot which shows up distinctly against the brown color of the egg. This is called the micropyle.

Summary.

The Mydas fly is a representative of one of the primitive families of Diptera. A study of the internal anatomy confirms the evidence derived from the external anatomy and other sources in regard to their relative systematic position.

The alimentary canal is a generalized food tube which shows no particular specialization in any direction. The length of the tract and the structure of the mouthparts indicates that the fly is carnivorous in its food habits.

The concentration of ganglia has not proceeded to any great degree, while centralization of the whole system is greatly like that of lower Diptera.

The chorion of the egg is composed of a hard chitinous material and precludes the idea that the female is able to deposit mature larvæ. This characteristic of the eggs as found in the abdomen of the female necessitates a longer or shorter period of incubation after the egg has been deposited.

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EXPLANATION OF PLATES.

PLATE I.

Fig. I. A dorsal view of the nervous system showing the position of the brain, ganglia, and the main nerves which branch from the ventral nerve trunk.
Fig. II. A dorsal view of the alimentary canal.
Fig. III. A dorsal view of the female reproductive system, which shows all parts of the system except the ovaries.
Fig. IV. The abdomen of the female Mydas fly showing the arrangement of the eggs.
Fig. V. The male reproductive system shown in a dorsal view.
Fig. VI. Side view of the brain of the Mydas fly with the optic lobes removed.
Fig. VII. Dorsal view of the brain as it lies in the head.
Fig. VIII. Dorsal view of the brain after it has been tipped forward in order to show the sub-oesophageal ganglion.

PLATE II.

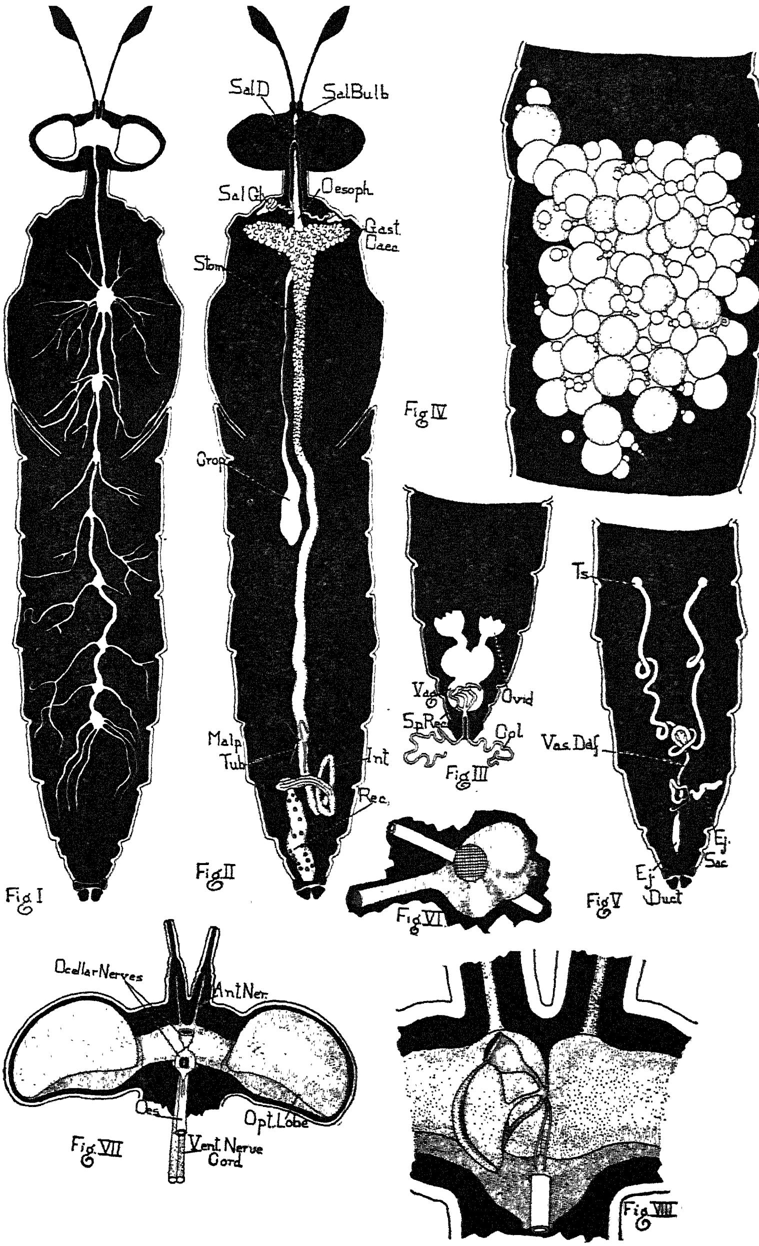
Fig. I. Longitudinal section through the oesophageal valve, oesophagus, gastric caeca, and the tube leading to the crop.
Fig. II. A view of part of the oesophagus taken from a cross-section.
Fig. III. Part of the cross-section through the mid-gut, which shows the arrangement of the epithelium into papillæ-like projections.
Fig. IV. Cross-section of a salivary gland.

PLATE III.

Fig. I. Cross-section of a malpighian tubule.
Fig. II. Longitudinal section of a malpighian tubule.
Fig. III. Longitudinal section through the pyloric valve showing the insertion of a malpighian tubule.
Fig. IV. Cross-section through the hind gut.
Fig. V. Longitudinal section of the rectum which is cut through a rectal papilla.

ABBREVIATIONS.

Ant. Nerv......Antennal Nerves.
Circ. Mus.......Circular Muscle.
Col.............Colleteria.
Ej. Duct........Ejaculatory Duct.
Ej. Sac.........Ejaculatory Sac.
Epith..........Epithelium.
Gast. Caec......Gastric Caecæ.
Int.............Intestine.
Long. Mus......Longitudinal Muscle.
Malp. Tub......Malpighian Tubule.
Oes.............Oesophagus.
Opt. Lobe.......Optic Lobe.
Ovid............Oviduct.
Per. Memb........Peritrophic Membrane.
Perit. Memb......Peritoneal Membrane.
Rec...............Rectum.
Sal. Bulb.........Salivary Bulb.
Sal. D............Salivary Duct.
Sal. Gl...........Salivary Gland.
Sp. Rec...........Sperm Receptacle.
Stom.............Stomach.
Trach............Tracheoles.
Ts................Testes.
Vag..............Vagina.
Vas. Def..........Vas Deferens.
Vent. Nerv. Cord. Ventral Nerve Cord.


Sal D
Sal Bulb
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Oesoph.
Gast. Caec.
Stom
Crop
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Fig I
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Vag
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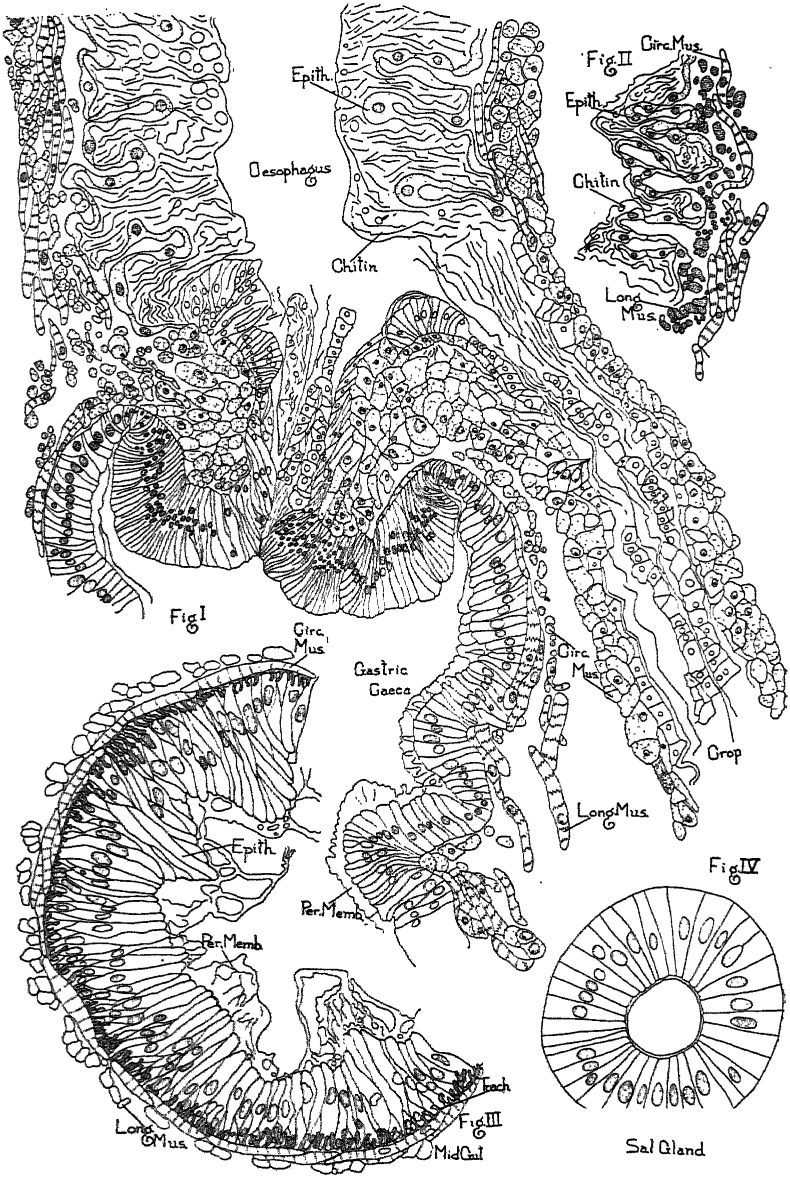
Fig III
Ts
Vas Def
Ej. Sac
Ej. Duct
Fig V
Fig VI
Ocellar Nerves
Ant Ner.
Oes
Opt. Lobe
Vent Nerve Cord
Fig VII
Fig VIII


Epith.
Oesophagus
Chitin
Fig.II
Circ.Mus.
Epith.
Chitin
Long Mus.
Fig.I
Circ. Mus.
Gastric Caeca
Circ. Mus.
Crop
Long.Mus.
Epith.
Per.Memb.
Per.Memb.
Fig.IV
Trach
Fig.III
Long Mus.
Mid Gut
Sal Gland

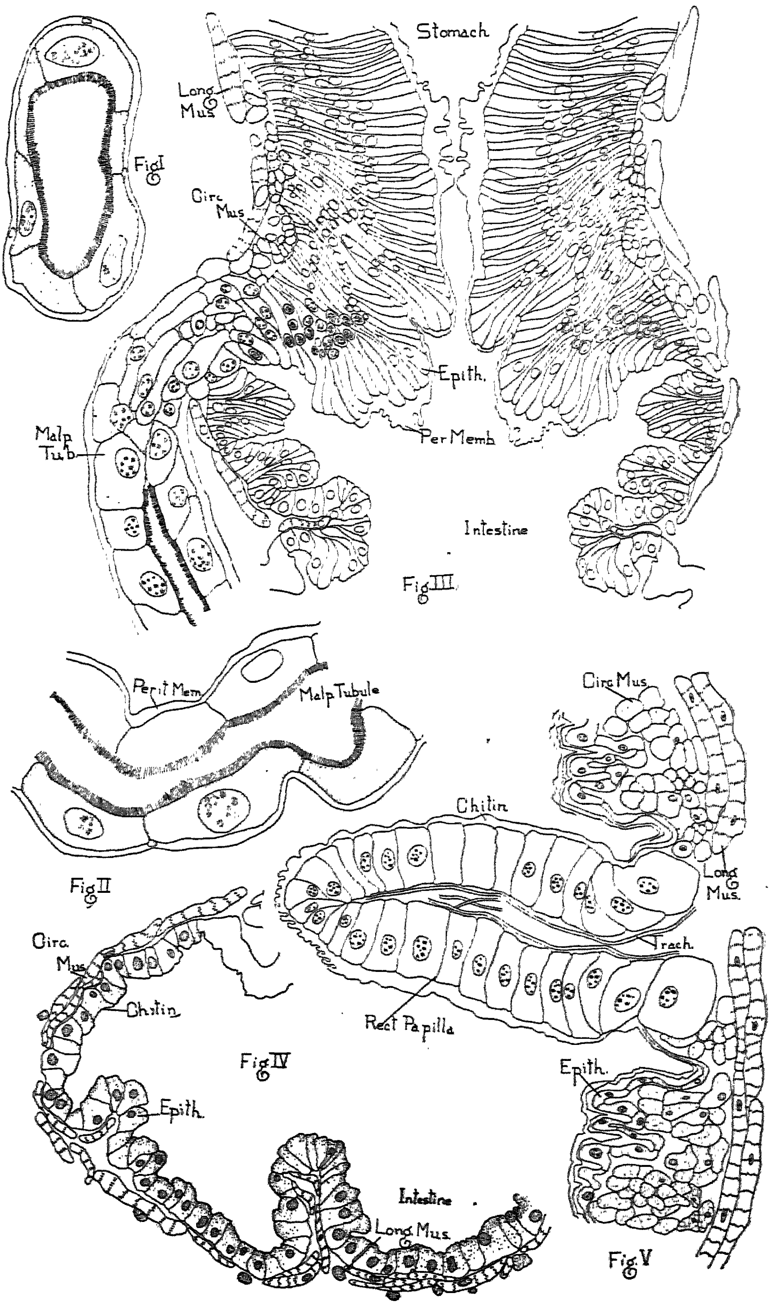


Fig I
Stomach
Long. Mus.
Circ. Mus.
Epith.
Per Memb.
Malp. Tub.
Intestine
Fig III
Perit Mem.
Malp Tubule
Fig II
Circ Mus.
Chitin
Long. Mus.
Trach.
Rect Papilla
Circ. Mus.
Chitin
Fig IV
Epith.
Intestine
Long. Mus.
Epith.
Fig V

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1929.*

JOHN H. SCHAFFNER.

The additions to the State Herbarium have been both numerous and important, many showing decided extensions of known ranges and others adding species new to the list. Dr. F. W. Pennell has completed his monograph of the North American species of Agalinis and our list is now corrected in agreement with his determinations. Dr. E. T. Wherry has studied our species of Phlox. Thus we are learning not only what we have but the exact localities where botanists can find the plants. Our specimens of Helianthus were all studied by Prof. Elba E. Watson of the Michigan Agricultural College and a revised list of the species is presented below, corresponding to his recently published work—Contributions to a Monograph of the Genus Helianthus. Mich. Acad. Sci. Arts and Letters 9:305–475. 1929. The study of a genus by a specialist nearly always brings improvement and change which means progress. Change brings temporary inconvenience, but the individual must necessarily be readjusting himself to an advancing world, in plant taxonomy and geography as well as in all other progressive sciences.

4. *Botrychium lanceolatum* (Gmel.) Angs. Lanceleaf Grape-fern. "Common in Beech-Maple woods in Western half of Monroe Twp.," Ashtabula Co. Lawrence E. Hicks.

20. *Asplenium pinnatifidum* Nutt. Pinnatifid Spleenwort. Buchtel, Athens Co. Len Stephenson.

26. *Asplenium montanum* Willd. Mountain Spleenwort. "Abundant on all of the cliffs on east side of gulch." White's Gulch, Liberty Twp., Jackson Co. Laurel Twp., Hocking Co. Floyd Bartley and Leslie L. Pontius.

40. *Dennstaedtia punctilobula* (Mx.) Moore. Boulder-fern. Red Hills region, along Duncan Run, Genoa Twp. and Highbanks, Liberty Twp., Delaware Co. R. B. Gordon and F. B. Chapman.

47. *Azolla caroliniana* Willd. Carolina Azolla. "Abundant in the north end of Baumgardner's Lake," Jackson Twp., Franklin Co. Arthur R. Harper. (This was planted there in the spring of 1929 by Lawrence E. Hicks.—J. H. S.) Portage Lakes, near Akron, Summit Co. Glenn W. Blaydes.

53. *Equisetum laevigatum* A. Br. Smooth Scouring-rush. Licking Narrows, Toboso, Licking Co. R. B. Gordon and Hiram F. Thut. Big Darby Creek, Prairie Twp., Franklin Co. R. B. Gordon.

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*Papers from the Department of Botany, The Ohio State University, No. 255.

54. *Equisetum fluviatile* L. Water Horsetail. Bennett Lake, Washington Twp., Holmes Co. Also in Long Pond, Coventry Twp., Summit Co.; Muzzy Lake, Rootstown Twp., Portage Co.; and Black Run Pond, Mentor Twp., Lake Co. Lawrence E. Hicks. Indian Lake, Logan Co. W. H. Camp.

59. *Lycopodium porophilum* Lloyd & Und. Rock Club-moss. Hocking Twp., Fairfield Co. L. E. Hicks and E. S. Thomas. Ofer Hollow, Jackson Co. Floyd Bartley and Leslie L. Pontius.

61. *Lycopodium clavatum* L. Common Club-moss. Toboso, Licking Co. R. B. Gordon and Hiram F. Thut. Corning, Perry Co. R. D. Book.

69. *Pinus rigida* Mill. Pitch Pine. Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

70. *Pinus virginiana* Mill. Scrub Pine. Byington, Mifflin Twp., Pike Co. Reported by E. S. Thomas.

71. *Pinus echinata* Mill. Short-leaf Yellow Pine. Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

76. *Taxus canadensis* Marsh. American Yew. Put-in-Bay (South Bass) Island, Ottawa Co. R. C. Osburn and L. H. Tiffany.

92. *Potamogeton lucens* L. Shining Pondweed. Baumgardner's Pond, Jackson Twp., Franklin Co. Hiram F. Thut.

100. *Potamogeton pusillus* L. Small Pondweed. Baumgardner's Pond, Jackson Twp., Franklin Co. Hiram F. Thut.

121. *Typha angustifolia* L. Narrow-leaf Cat-tail. Jerusalem Twp., Lucas Co. Louis W. Campbell. Oak Hill, Jackson Co. Conrad Roth. Near Columbus, Franklin Co. R. B. Gordon and H. F. Thut.

130. *Lemna cyclostasa* (Ell.) Chev. Valdivia Duckweed. Mentor Twp., Lake Co. L. E. Hicks.

132. *Wolffiella floridana* (J. D. Smith) Thomp. Florida Wolffiella. Green Twp., Summit Co.; Suffield Twp., Portage Co. L. E. Hicks.

133. *Wolffia columbiana* Karst. Columbia Wolffia. Collected in Ross, Licking, Richland, Summit, Portage, and Lake Counties by L. E. Hicks.

134. *Wolffia punctata* Griseb. Punctate Wolffia. Near Fredericktown, Knox Co. L. E. Hicks.

138. *Cyperus inflexus* Muhl. Awned cyperus. Abundant in ooze at north end of Baumgardner's Lake, Jackson Twp., Franklin Co. Arthur R. Harper.

139.2. *Cyperus retrofractus* Torr. Rough Cyperus. Benton Twp., Hocking Co. Floyd Bartley.

176. *Rynchospora glomerata* (L.) Vahl. Clustered Beak-rush. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius. Silver Lake, near New Carlisle, Clark Co. John H. Schaffner.

181. *Scleria verticillata* Muhl. Low Nut-rush. Silver Lake, near New Carlisle, Clark Co. John H. Schaffner; Ira May Swamp, Wayne Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

201. *Carex trisperma* Dew. Three-fruited Sedge. Hillsboro, Highland Co. Katie M. Roads.

223. *Carex leptalea* Wahl. Bristle-stalked Sedge. Hillsboro, Highland Co. Katie M. Roads.

227. *Carex hirtifolia* Mack. Pubescent Sedge. Hillsboro, Highland Co. Katie M. Roads.

278. *Carex folliculata* L. Long Sedge. "Abundant in swamps," Wayne Twp., Ashtabula Co. Lawrence E. Hicks.

340. *Eragostis capillaris* (L.) Nees. Capillary Love-grass. Hillsboro, Highland Co. Katie M. Roads.

345. *Korycarpus arundinaceus* Zea. American Korycarpus. Jefferson Twp., Adams Co. Conrad Roth.

349. *Phragmites phragmites* (L.) Karst. Common Reed-grass. Silver Lake, near New Carlisle, Clark Co. John H. Schaffner. Also near Lancaster, Fairfield Co. Glenn W. Blaydes.

352. *Arrhenatherum elatius* (L.) Beauv. Oat-grass. Bexley, Franklin Co. E. S. Thomas.

353. *Trisetum pennsylvanicum* (L.) Beauv. Marsh False-oats. "In a swamp near Hillsboro." Liberty Twp., Highland Co. Katie M. Roads.

359. *Nothoholcus lanatus* (L.) Nash. Velvet-grass. South Perry, Hocking Co. E. S. Thomas. Also Loudonville, Ashland Co. Glenn W. Blaydes. Conneaut Twp. and Monroe Twp., Ashtabula Co. Lawrence E. Hicks.
372. *Hordeum vulgare* L. Common Barley. "Escaped along roadside," Fredericktown, Knox Co. Lawrence E. Hicks.
372a. *Hordeum vulgare trifurcatum* Schlecht. Hooded Barley. "Escaped along roadside," Fredericktown, Knox Co. Lawrence E. Hicks.
383. *Sporobolus asper* (Mx.) Kunth. Long-leaf Rush-grass. Minerva Park, Franklin Co. R. B. Gordon and F. M. Chapman. Earlier specimens in the herbarium are from "Steelton," "Sellsville," in Columbus.
403. *Muhlenbergia umbrosa* Scribn. Wood Muhlenbergia. "In woodland," East Williamsfield, Ashtabula Co. Lawrence E. Hicks.
410. *Aristida dichotoma* Mx. Poverty-grass. "In woodland," East Williamsfield, Ashtabula Co. Lawrence E. Hicks.
415a. *Phalaris arundinacea picta* L. Ribbon-grass. "Escaped along roadside near Kellogsville," Ashtabula Co. Lawrence E. Hicks.
455. *Echinochloa walteri* (Pursh) Nash. Marsh Cockspur-grass. Williamsfield Twp., Ashtabula Co. Lawrence E. Hicks.
464. *Zizania aquatica* L. Wild Rice. "Old canal bed," Wayne Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
469.1. *Andropogon elliottii* Chapm. Elliott's Beard-grass. Near New Straitsville, Perry Co. Lawrence E. Hicks, Edward S. Thomas and Len. Stephenson.
475. *Lilium superbum* L. Turk's-cap Lily. Jackson Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.
477. *Lilium philadelphicum* L. Philadelphia Lily. Shawnee State Forest, Scioto Co. R. B. Gordon and Conrad Roth.
481.2. *Nothoscordum bivalve* (L.) Britt. False Garlic. Greenbrier Twp., Adams Co. E. Lucy Braun. (Braun Herbarium).
482. *Allium tricoccum* Ait. Wild Leek. "In woods along Conneaut R." Farnham, Ashtabula Co. Lawrence E. Hicks.
487.1. *Scilla nonscripta* Hoff. & Link. Common Blue Squill. "Spreading in a vacant lot." Hillsboro, Highland Co. From western Europe. Kate M. Roads.
487.2. *Scilla sibirica* Andr. Siberian Squill. From Russia and Siberia. Propagates itself from seed and spreads when planted about dwellings. Columbus, Franklin Co. John H. Schaffner.
511. *Disporum lanuginosum* (Mx.) Nich. Hairy Disporum. Harrison Twp., Ross Co. Floyd Bartley.
519. *Clintonia umbellulata* (Mx.) Torr. White Clintonia. Abundant, East Pike Run, Salt Creek Twp., Hocking Co. Floyd Bartley and Leslie L. Pontius.
532. *Tradescantia pilosa* Lehm. Zigzag Spiderwort. Paint Creek Gorge, Ross Co. Floyd Bartley and Leslie L. Pontius. "Common in woodlands," Twin Twp., Preble Co. Lawrence E. Hicks.
542. *Juncus marginatus* Rostk. Grass-leaf Rush. Wayne Twp., Ashtabula Co. Lawrence E. Hicks.
544. *Juncus articulatus* L. Jointed Rush. Silver Lake, near New Carlisle, Clark Co. John H. Schaffner.
545. *Juncus torreyi* Cov. In pond near Columbus, Franklin Co. R. B. Gordon and H. F. Thut.
547. *Juncus brachycephalus* (Engelm.) Buch. Small-headed Rush. Liberty Twp., Highland Co. Katie M. Roads.
553. *Xyris flexuosa* Muhl. Slender Yellow-eyed-grass. Springfield Twp., Lucas Co. Louis W. Campbell.
558. *Iris cristata* Ait. Crested Dwarf Iris. Pure white form. East Pike Run, Hocking Co. Floyd Bartley.
556.3. *Iris virginica* L. Virginia Blue-flag. All of our Blue-flags, which have heretofore gone under the name of *Iris versicolor*, belong to this species, except one specimen. Generally distributed in the state in suitable habitats from Williams, Hamilton (Edgar Anderson) and Greene counties north-eastward to Cuyahoga (Edgar Anderson) and Perry. Conneaut R., Conneaut Twp., Ashtabula Co. L. E. Hicks.

557. *Iris versicolor* L. Northern Blue-flag. According to the study of Edgar Anderson, all of our Blue-flags, which have heretofore gone under the name of *Iris versicolor*, belong to the preceding number. This species probably only occurs in north-eastern Ohio. The only specimen in the herbarium is from Ashtabula county. Also new specimen from Conneaut R., Conneaut Twp., Ashtabula Co. L. E. Hicks.

ORDER SCITAMINALES.

Cannaceæ. Canna Family.

563.2. *Canna generalis* Bail. Common Canna. Spontaneous from seed; surviving only for the season. Columbus, Franklin Co. John H. Schaffner.

567. *Fissipes acaule* (Ait.) Small. Moccasin-flower. White's Gulch, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

577. *Blephariglottis lacera* (Mx.) Farw. Ragged Fringed-orchis. Springfield Twp., Lucas Co. Louis W. Campbell.

580. *Blephariglottis peramoena* (Gr.) Rydb. Fringeless Purple Orchis. Pee Pee Twp., Pike Co., White's Gulch, Jackson Co., Higby Prairie, Ross Co. Floyd Bartley and Leslie L. Pontius.

582. *Isotria verticillata* (Willd.) Raf. Whorled Isotria. Ofer Hollow, Jackson Co. Floyd Bartley and Leslie L. Pontius. "Neotoma," Good Hope Twp., Hocking Co. E. S. Thomas.

585. *Limodorum tuberosum* L. Limodorum. Shawnee State Forest, Scioto Co. Roscoe Franks and Conrad Roth.

588. *Ibidium cernuum* (L.) House. Nodding Lady's-tresses. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

593. *Peramium pubescens* (Willd.) MacM. Downy Rattlesnake-plantain. Big Darby Creek, Franklin Co. E. S. Thomas.

594. *Malaxis unifolia* Mx. Green Addermouth. Rock Hill, Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

596. *Liparis loeselii* (L.) Rich. Fen Twayblade. "In a swamp" near Hillsboro, Highland Co. Katie M. Roads. Cranberry Island, Buckeye Lake, Licking Co. Lawrence E. Hicks.

599. *Corallorrhiza corallorrhiza* (L.) Karst. Early Coral-root. Cantwell Cliffs, Hocking Co. Glenn W. Blaydes.

604. *Magnolia tripelata* L. Umbrella Magnolia. Byers Hollow, Saltcreek Twp., Hocking Co., also Byers Hollow, Eagle Twp., Vinton Co. Floyd Bartley and Leslie L. Pontius.

608. *Ranunculus micranthus* Nutt. Rock Crowfoot. "In two woods and along small stream." Liberty Twp., Highland Co. Katie M. Roads.

612. *Ranunculus bulbosus* L. Bulbous Buttercup. "Abundant in a lawn; introduced in grass seed." Hillsboro, Highland Co. Katie M. Roads.

626. *Nigella damascena* L. Love-in-a-mist. Escaped. Columbus, Franklin Co. Mrs. W. H. Camp.

634. *Anemone cylindrica* Gr. Long-fruited Anemone. Springfield Twp., Lucas Co. Louis W. Campbell.

648. *Isopyrum biternatum* (Raf.) T & G. False Rue-anemone. Williamsport, Ross Co. Leslie L. Pontius.

652. *Parnassia caroliniana* Mx. Carolina Grass-of-Parnassus. North Union Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

657.1. *Berberis thunbergii* DC. Japansee Barberry. Escaped in swamp woods, Delaware, Delaware Co. G. W. Blaydes.

664. *Drosera intermedia* Hayne. Spatulate Sundew. Springfield Twp., Lucas Co. Also in Spencer Twp. Louis W. Campbell.

677. *Capnoides sempervirens* (L.) Borck. Pink Corydalis. Spencer Twp., Lucas Co. Louis W. Campbell. Green Twp., Ross Co. Floyd Bartley.

694. *Radicula hispida* (Desv.) Britt. Hispid Yellow-cress. Spencer Twp., Lucas Co. Louis W. Campbell.

700. *Lepidium draba* L. Hoary Peppergrass. Columbus, Franklin Co. C. J. Willard.

701.1. *Lepidium perfoliatum* L. Perfoliate Peppergrass. "In a small pasture lot," Hillsboro, Highland Co. Katie M. Roads.

703. *Thlaspi arvense* L. Field Penny-cress. Lucas Co. L. W. Campbell.
706. *Sophia pinnata* (Walt.) Howell. Pinnate Tansy-mustard. New Vienna, Clinton Co. Katie M. Roads.
708. *Cheirinia cheiranthoides* (L.) Link. Worm-seed Mustard. Amanda Twp., Fairfield Co. Floyd Bartley and Leslie L. Pontius.
708.1. *Cheirinia inconspicua* (Wats.) Britt. Prairie Cheirinia. From the west. Milford, Clermont Co. "Alluvial soil, cornfields." E. Lucy Braun.
709. *Cheirinia repanda* (L.) Link. Repand cheirinia. Washington Court House, Fayette Co. C. J. Willard.
716. *Arabidopsis thaliana* (L.) Britt. Mouse-ear Cress. Harrison Twp., Ross Co. Floyd Bartley.
753. *Cakile edentula* (Bigel.) Hook. Sea Rocket. Toledo, Lucas Co. R. T. Wareham.
754. *Polonisia graveolens* Raf. Clammy-weed. Little Cedar Point, Jerusalem Twp., Lucas Co. Louis W. Campbell; Toledo, Lucas Co. R. T. Wareham.
774.1. *Linum striatum* Walt. Ridged Flax. "Growing in a bog." Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
807. *Dicrophyllum marginatum* (Pursh) K. & G. Snow-on-the-mountain. A waif in Columbus, Franklin Co. John H. Schaffner. "A common escape in Twin Twp.," Preble Co. Lawrence E. Hicks.
812. *Chamaesyce polygonifolia* (L.) Small. Knotweed Spurge. Toledo, Lucas Co. R. T. Wareham.
814. *Callitriche austini* Engelm. Terrestrial Water-starwort. Rock House, Hocking Co., "Cabin Cove," Jackson Twp. Franklin Co. R. B. Gordon.
815. *Callitriche palustris* L. Vernal Water-starwort. Delaware, Delaware Co. Glenn W. Blaydes.
827. *Napaea dioica* L. Glade-mallow. Prospect, Marion Co. E. N. Transeau.
829. *Hibiscus moscheutos* L. Swamp Rose-mallow. Stage's Pond near Ashville, Pickaway Co. Flowers white to pink and also sulphur yellow. Lloyd M. Shupe, Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
830. *Hibiscus militaris* Cav. Halberd-leaf Rose-mallow. Prospect, Marion Co. E. N. Transeau. Calamus pond, Wayne Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley. Sims Creek, Village of Gallia, Gallia Co. W. H. Camp.
840. *Hypericum cistifolium* L. Round-podded St. John's-wort. North Union and Colerain Twps., Ross Co. Floyd Bartley and Leslie L. Pontius.
848. *Hypericum drummondii* (Grev. & Hook.) T. & G. Drummond's St. John's-wort. Near Barnesville, Belmont Co. Collected by Emma E. Laughlin. Huntington Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
849. *Sarothra gentianoides* L. Orange-grass. Springfield Twp., Lucas Co. Louis W. Campbell. Jackson, Jackson Co. W. G. Stover.
850. *Triadenum virginicum* (L.) Raf. Marsh St. John's-wort. Amanda Twp., Fairfield Co. Floyd Bartley and Leslie L. Pontius.
853.1. *Hudsonia tomentosa* Nutt. Woolly Hudsonia. "A few plants growing in a sandy area near the Indiana-Ohio boundary line." Southwest of Montpelier, Williams Co. Lawrence E. Hicks.
874. *Viola lanceolata* L. Lanceleaf Violet. Springfield Twp., Lucas Co. Louis W. Campbell.
884. *Viola sagittata* Ait. Arrowleaf Violet. Cantwell Cliff, Hocking Co. Floyd Bartley.
908. *Lychnis alba* Mill. White Lychnis. Clinton Twp., Franklin Co. and Shelby, Richland Co. R. A. Wareham. Also Columbus, Franklin Co. L. E. Hicks.
912. *Silene latifolia* (Mill.) Britt. & Rendle. Bladder Campion. Kellogsville, Ashtabula Co. Lawrence E. Hicks.
920.1. *Silene wherryi* Small. Wherry's Catchfly. Mifflin Twp., (1⅓ mi. east of Sinking Spring), Pike Co. E. T. Wherry. Transfer the record of Silene caroliniana Walt. from Fort Hill, Highland Co., collected by Katie M. Roads in 1925 to this new species also. Along with other characters this new species can be distinguished from Silene caroliniana by its calyx

equaling the petal claws and being densely covered with pilose non-glandular hairs and by the style which is about as long as the ovulary.

923. *Vacaria vacaria* (L.) Britt. Cowherb. Benton Twp., Ottawa Co. Louis W. Campbell.

925. *Dianthus armeria* L. Deftford Pink. Howard, Knox Co. Lawrence E. Hicks.

933. *Allionia nyctaginea* Mx. Heart-leaf Umbrella-wort. Toboso, Licking Co. John H. Schaffner.

952. *Chenopodium leptophyllum* (Moq.) Nutt. Narrowleaf Goosefoot. Hillsboro, Highland Co. Katie M. Roads.

976. *Pleuropterus zuccarinii* Small. Japanese Knotweed. "Found in two localities near Camden, Preble Co." Lawrence E. Hicks.

980. *Tracaulon arifolium* (L.) Raf. Halberd-leaf. Tear-thum. Liberty Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.

992. *Persicaria orientalis* (L.) Spach. Prince's-feather. Gratis, Preble Co. Lawrence E. Hicks.

1006. *Dasiphora fruticosa* (L.) Rydb. Shrubby Cinquefoil. North Union Twp., Ross Co. Floyd Bartley and Leslie L. Pontius. Silver Lake, near New Carlisle, Clark Co. John H. Schaffner.

1009. *Potentilla recta* L. Upright Cinquefoil. West of Chillicothe, Ross Co. Floyd Bartley and Leslie L. Pontius.

1030. *Rubus odoratus* L. Rose-flowered Raspberry. Paint Creek Gorge. Ross Co. Floyd Bartley and Leslie L. Pontius.

1034. *Filipendula rubra* (Hill.) Rob. Queen-of-the-prairie. North Union Twp., Ross Co. Floyd Bartley and Leslie L. Pontius. Bushville, Ashtabula Co. Lawrence E. Hicks.

1034.1. *Filipendula ulmaria* (L.) Maxim. Meadow-queen. From Europe. "Escaped from cultivation along roadside near Kellogsville, Ashtabula Co." Lawrence E. Hicks.

1104. *Baptisia leucantha* T. & G. Large White False-indigo. Madison Twp., Fairfield Co. E. S. Thomas, L. E. Hicks, and C. F. Walker.

1106. *Lupinus perennis* L. Wild Lupine. Springfield Twp., Lucas Co. Louis W. Campbell.

1112. *Trifolium agrarium* L. Yellow Hop Clover. Scioto Furnace, Scioto Co. Conrad Roth.

1113. *Trifolium procumbens* L. Low Hop Clover. Hillsboro, Highland Co. Katie M. Roads. Also "Swamp woods," Delaware, Delaware Co. G. W. Blaydes.

1116. *Trifolium arvense* L. Rabbit-foot Clover. Hillsboro, Highland Co. Katie M. Roads.

1118. *Trifolium reflexum* L. Buffalo Clover. On "Devil's Back Bone," Washington Twp., Pickaway Co. Leslie L. Pontius.

1157. *Lespedeza virginica* (L.) Britt. Slender Bush-clover. Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1161.1. *Vicia villosa* Roth. Hairy Vetch. Hillsboro, Highland Co. Katie M. Roads.

1166. *Vicia sativa* L. Common Vetch. Hillsboro, Highland Co. Katie M. Roads.

1170. *Lathyrus palustris* L. Marsh Pea. Prairie Twp., Franklin Co. R. B. Gordon.

1173.1. *Lathyrus latifolius* L. Everlasting Pea. "Along railroad near Geneva," Ashtabula Co. Lawrence E. Hicks.

1187. *Micranthes pennsylvanica* (L.) Haw. Pennsylvania Saxifrage. Delaware, Delaware Co. Glenn W. Bladyes. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1189. *Sullivantia sullivantii* (T. & G.) Britt. Sullivantia. Near Byington, Mifflin Twp., Pike Co. Reported by E. S. Thomas.

1190. *Tiarella cordifolia* L. False Mitrewort. East Pike Run, Hocking Co. Floyd Bartley. Also Mechanicsburg, Champaign Co. Chas. B. Wing.

1201. *Dirca palustris* L. Leatherwood. Growing with Arbor vitae at Cedar Falls, Adams Co. E. F. McCarthy and R. B. Gordon.

1204. *Rhamnus lanceolata* Pursh. Lanceleaf Buckthorn. Greer, Knox Co. R. B. Gordon. Springfield Twp., Ross Co. Floyd Bartley.

1207. *Ceanothus americanus* L. Common New Jersey Tea. Springfield Twp., Lucas Co. Louis W. Campbell.

1214. *Ampelopsis cordata* Mx. Heartleaf Ampelopsis. Crown City, Gallia Co. W. H. Camp.

1219. *Euonymus americanus* L. American Strawberry-bush. White's Gulch, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1239. *Toxicodendron vernix* (L.) Ktz. Poison Sumac. Cedar Swamp, Champaign Co. Glenn W. Blaydes. Liberty Twp., Ross Co.; Amanda Twp., Fairfield Co. Floyd Bartley and Leslie L. Pontius. "In swamp along Kokosing R., 2 miles north of Fredericktown," Knox Co. Lawrence E. Hicks.

1254. *Cannabis sativa* L. Hemp. "Common for about a mile in pasture fields along Twin Creek," Lanier Twp., Preble Co. Lawrence E. Hicks.

1285.1. *Alnus alnus* (L.) Britt. European Alder. "Escaped from cultivation along stream; trees of various size." Minerva Park, Franklin Co. R. B. Gordon and F. M. Chapman.

1324. *Philadelphus coronarius* L. Garden Mock-orange. Hillsboro, Highland Co. Katie M. Roads.

1338. *Epilobium lineare* Muhl. Linear-leaf Willow-herb. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1348. *Hartmannia speciosa* (Nutt.) Small. White Evening-primrose. St. Marys, Auglaize County. Wm. Kayser. Accidental in Columbus, Franklin Co. Glenn W. Blaydes.

1358 a. *Cucurbita pepo ovifera* Bail. Yellow-flowered Gourd. "A large number of plants found growing along west bank of Twin Creek, 2 mi. south of West Alexandria," Preble Co. Lawrence E. Hicks.

1399. *Chamaedaphne calyculata* (L.) Moench. Leather-leaf. "In small Sphagnum bog Nesmith Lake, Summit Co. East of Richmond Center, Ashtabula Co. Lawrence E. Hicks.

1401. *Oxydendrum arboreum* (L.) DC. Sorrel-tree. Paint Creek Gorge, Ross Co. Floyd Bartley and Leslie L. Pontius.

1402. *Epigaea repens* L. Trailing Arbutus. Harrison Twp., Ross Co. Floyd Bartley.

1403. *Gaultheria procumbens* L. Creeping Wintergreen. Harrison Twp., Ross Co. Floyd Bartley.

1410. *Vaccinium atrococcum* (Gr.) Heller. Dark Blueberry. "In bog, terminal moraine." Beach City, Sugar Creek Twp., Stark Co. W. H. Camp.

1415.2. *Halesia carolina* L. Silver-bell. Porter Twp., Scioto Co. Conrad Roth.

1418. *Phlox ovata* L. Mountain Phlox. Springfield Twp., Lucas Co. Louis W. Campbell.

1422. *Phlox stolonifera* Sims. Creeping Phlox. Ofer Falls, Coal Twp., Jackson County. Floyd Bartley.

1423. *Phlox subulata* L. Mr. Edgar T. Wherry studied our species of Phlox in April and has recently published a revision of this species dividing our material into two new varieties as given below. See Bartonia *11:* 27, 1929. It would now be interesting to find the line across the state which separates the two varieties or regions in which the two might overlap.

1423.a. *Phlox subulata ciliata* Wherry. N. Var. Northern Ground Phlox. Defiance, Knox, Medina, Lorain, Cuyahoga, Portage, Lake.

1423.b. *Phlox subulata australis* Wherry. N. Var. Southern Ground Phlox. Harlem, Delaware Co. (E. T. Wherry), Franklin, Licking, Muskingum, Guernsey, Fairfield; Sinking Springs, Highland Co. (E. T. Wherry); Adams, Scioto, Lawrence.

1468. *Gentiana andrewsii* Griseb. Closed Gentian. Along Sims Creek, Village of Gallia, Gallia Co. W. H. Camp. More than 100 white-flowered specimens with no blue ones anywhere nearby. Jerusalem Twp., Lucas Co. Louis W. Campbell.

1472. *Obolaria virginica* L. Pennywort. Harrison Twp., Ross Co. Floyd Bartley.

1473. *Bartonia virginica* (L.) B. S. P. Yellow Bartonia. Higby Prairie, Ross Co. Floyd Bartley and Leslie L. Pontius.

1479. *Apocynum pubescens* R. Br. Velvet Dogbane. "On dry sandy hill," Beach City, Sugar Creek Twp., Stark Co. W. H. Camp.

1487. *Asclepias sullivantii* Engelm. Sullivant's Milkweed. Darby Twp., Pickaway Co. "Also seen in Fayette Co., two localities between Mt. Sterling and Washington Court House." E. S. Thomas and R. B. Gordon.

1493. *Asclepias verticillata* L. Whorled Milkweed. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1515. *Solanum rostratum* Dunal. Columbus, Franklin Co. A rare weed. John H. Schaffner.

1517.1. *Verbascum phlomoides* L. Clasping-leaf Mullen. Hamilton, Butler Co. From Europe. Mrs. Lulu Brand. (Braun Herbarium).

1521 a. *Chelone glabra linifolia* Coleman. Reported with half-tone habitat illustration from near Whitehouse, Lucas Co. in Bartonia, 1927-1928, p. 23. by F. W. Pennell and E. T. Wherry.

1529. *Conobea multifida* (Mx.) Benth. Conobea. On limestone. "The Point," Paint Twp., Ross Co. E. S. Thomas and R. B. Gordon. Also north Union Twp. and Springfield Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1535. *Veronica anagallis-aquatica* L. Water Speedwell. North Union Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1552. *Aureolaria pedicularia* (L.) Benth. Fernleaf False Foxglove. Springfield Twp., Lucas Co. Louis W. Campbell.

1555. *Aureolaria flava* (L.) Farw. Smooth False Foxglove. Springfield Twp., Lucas Co. Louis W. Campbell.

According to F. W. Pennell's treatment our species of Agalinis are as follows:

1556. *Agalinis purpurea* (L.) Pennell. Large Purple Agalinis. Rather General.

1557. *Agalinis paupercula* (Gr.) Britt. Small Purple Agalinis. Erie, Ottawa, Lucas.

1558. *Agalinis tenuifolia* (Vahl.) Raf. Slender Agalinis. Lucas, Erie (Moseley), Fulton (Pennell), Stark, Wayne, Washington, Licking, Fairfield, Gallia, Adams.

1558a. *Agalinis tenuifolia macrophylla* (Benth.) Blake. Auglaize, Fulton, Lucas, Erie (Pennell), Ottawa (Pennell), Wood, Monroe, Mahoning (Pennell), Belmont, Franklin, Madison, Fairfield (Pennell), Champaign (Pennell), Hocking, Clark, Greene, Clermont, Montgomery, Miami, Hamilton (Pennell).

1558b. *Agalinis tenuifolia parviflora* (Nutt.) Pennell. Erie Co. (Pennell).

1559. *Agalinis skinneriana* (Wood) Britt. Skinner's Agalinis. Wood Co.

1561. *Castilleja coccinea* (L.) Spreng. Scarlet Painted-cup. "Very plentiful at place where found; several acres covered with it." On state route 56, between Ash Cave and Hue, Benton Twp., Hocking Co. E. A. Albaugh. Ash Cave, Hocking Co. Kenneth Wright. Greer, Knox Co. R. B. Gordon. Springfield Twp., Lucas Co. Louis W. Campbell.

1579.1. *Catalpa ovata* Don. Japanese Catalpa. Head of Pine Run, Ashland Co. Several trees apparently growing wild among white pines in stream bottom." Lawrence E. Hicks.

1583. *Utricularia intermedia* Hayne. Flatleaf Bladderwort. Cedar Swamp, Champaign Co. Lawrence E. Hicks and Edward S. Thomas.

1598. *Myosotis virginica* (L.) B. S. P. Virginia Forget-me-not. Greer, Knox Co. R. B. Gordon.

1598.1. *Anchusa azurea* Mill. (*A. italica* Retz.). Azure Anchusa. Escaped in woods. From Europe. Wapakoneta, Auglaize Co. Wm. Kayser.

1607. *Echium vulgare* L. Blueweed. Conneaut, Ashtabula Co. Lawrence E. Hicks.

1616. *Trichostema dichotomum* L. Blue-curls. Flint Ridge, Hopewell Twp., Licking Co. Abundant in abandoned field. John H. Schaffner.

1627. *Scutellaria integrifolia* L. Hyssop Skullcap. Queer Creek, Hocking Co. Floyd Bartley and Leslie L. Pontius.

1638. *Clinopodium glabrum* (Nutt.) Ktz. Low Calamint. "Abundant on limestone." "The Point," Paint Twp., Ross Co. E. S. Thomas and R. B. Gordon.

1661. *Perilla frutescens* (L.) Britt. Perilla. "Abundant escape in many sections of Twin Twp.," Preble Co. Lawrence E. Hicks.

1663.1. *Meehania cordata* (Nutt.) Britt. Meehania. Blue Creek, Hocking Co. Floyd Bartley. Abundant near Ash Cave, Hocking Co. Lawrence E. Hicks and E. S. Thomas.

1672. *Lamium purpureum* L. Red Henbit. Concord Twp., Delaware Co. John H. Schaffner.

1696. *Plantago virginica* L. Dwarf Plantain. Gibsonville, Hocking Co. Chas. Ziegler. "Neotoma," Good Hope Twp., Hocking Co. E. S. Thomas.

1698. *Aralia spinosa* L. Angelica-tree. Twin Twp., Preble Co.; also in Lanier Twp. "Several thickets in western Monroe Twp.," Ashtabula Co. Lawrence E. Hicks.

1700. *Aralia nudicaulis* L. Wild Sarsaparilla. Springfield Twp., Ross Co., also in Harrison Twp., Ross Co. Floyd Bartley.

1704. *Eryngium aquaticum* L. Rattlesnake Master. Lynx P. O., Adams Co. Arthur R. Harper. Big Island Twp., Marion Co. E. N. Transeau. Monclova Twp., Lucas Co. L. W. Campbell and M. R. Van Cleve. Also Lucas Co. R. A. Schaller.

1752. *Houstonia purpurea* L. Large Houstonia. Paint Creek Gorge, Ross Co. Floyd Bartley and Leslie L. Pontius.

1753. *Houstonia ciliolata* Torr. Fringed Houstonia. Harrison and Springfield Twps., Ross Co. Floyd Bartley.

1760. *Diodia teres* Walt. Rough Buttonweed. Toad Heaven Hollow, Jackson Co. Floyd Bartley and Leslie L. Pontius.

1760.1. *Galium verum* L. Yellow Bedstraw. Circleville Twp., Pickaway Co. Floyd Bartley.

1766. *Galium mollugo* L. White Bedstraw. Jackson Twp., Pickaway Co. Floyd Bartley.

1777. *Viburnum dentatum* L. Toothed Arrow-wood. "Dry prairie on a steep clay bank." Big Darby Creek, Franklin Co. Edward S. Thomas. Also near Walhonding, Coshocton Co. C. F. Walker.

1779. *Viburnum cassinoides* L. Withe-rod. Ofer Hollow, Jackson Co. Leslie L. Pontius and Floyd Bartley.

1786.1. *Triosteum aurantiacum* Bickn. Scarlet-fruited Horse-gentian. Liberty Twp., Highland Co. Katie M. Roads.

1799. *Lonicera sullivantii* Gr. Sullivant's Honeysuckle. River Drive, Delaware, Delaware Co. Glenn W. Blaydes.

1802. *Diervilla diervilla* (L.) MacM. Brush-honeysuckle. Abundant. Colerain Tp., Ross Co. Floyd Bartley and Leslie L. Pontius. Walhonding, Coshocton Co. Lawrence E. Hicks.

1812. *Campanula rotundifolia* L. Harebell. "On limestone at 'The Point,' where Paint Creek joins the preglacial channel." Paint Twp., Ross Co. E. S. Thomas and R. B. Gordon.

1835. *Rudbeckia speciosa* Wend. Showy cone-flower. Wayne and Washington Twps., Pickaway Co.; Colerain Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.

Revised List of the Species of Helianthus.

1840. *Helianthus occidentalis* Ridd. Fewleaf Sunflower. Fulton, Erie, Franklin, Adams.

1841. *Helianthus microcephalus* T. & G. Small Wood Sunflower. Cuyahoga, Jackson.

1841.1. *Helianthus glaucus* Small. Glaucous Sunflower. Belmont, Lake, Cuyahoga, Wayne, Richland, Fairfield, Ross, Miami, Montgomery, Hamilton.

1842. *Helianthus giganteus* L. Giant Sunflower. From Ottawa, Wayne, and Fairfield counties westward.

1842.1. *Helianthus altissimus* L. Tall Sunflower. Williams County.

1843. *Helianthus maximiliani* Schrad. Maximilian's Sunflower. Lake, Franklin, Champaign, Hamilton, Auglaize Co. (Wm. Kayser). From the West.

1843.1. *Helianthus dalyi* Britt. Daly's Sunflower. Huron county (Schaffner).

1844. *Helianthus grosse-serratus* Mart. Sawtooth Sunflower. Erie, Wood, Huron, Franklin, Madison.

1844.1. *Helianthus instabilis* Wats. Unstable Sunflower. Auglaize, Cuyahoga, Madison, Clark.

1845. *Helianthus kellermani* Britt. Kellerman's Sunflower. Franklin County (Kellerman).
1846. *Helianthus divaricatus* L. Woodland Sunflower. Rather general.
1847. *Helianthus mollis* Lam. Hairy Sunflower. Lake, Erie, Franklin.
1848. *Helianthus doronicoides* Lam. Oblong-leaf Sunflower. Erie (Moseley), Franklin (Sullivant).
1849. *Helianthus decapetalus* L. Thinleaf Sunflower. General.
1850. *Helianthus tracheliifolius* Mill. Throatwort Sunflower. No specimens.
1850.1. *Helianthus brevifolius* Wats. Short-leaf Sunflower. Richmond, Lake County (Otto Hacker). Type. Painesville, Lake County (Hacker). Co-type.
1851. *Helianthus strumosus* L. Paleleaf Wood Sunflower. Madison, Defiance, Ottawa, Cuyahoga.
1852. *Helianthus hirsutus* Raf. Hirsute Sunflower. General.
1853. *Helianthus laetiflorus* Pers. Showy Sunflower. No specimens.
1854. *Helianthus tuberosus* L. Jerusalem Artichoke. General.
1855. *Helianthus annuus* L. Common Sunflower. General.
1856. *Helianthus petiolaris* Nutt. Prairie Sunflower. Lake, Huron, Belmont, Franklin Co. (Glenn W. Blaydes).
1859. *Coreopsis lanceolata* L. Lance-leaf Tickseed. Wapakoneta, Auglaize Co. Wm. Kayser.
1862. *Coreopsis verticillata* L. Whorled Tickseed. Silver Lake, near New Carlisle, Clark Co. John H. Schaffner.
1901. *Grindelia squarrosa* (Pursh.) Dun. Broad-leaf Gum-plant. Marysville, Union Co. Chas. Alspach.
1904. *Solidago squarrosa* Muhl. Stout Goldenrod. Rock Hill, Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
1908. *Solidago hispida* Muhl. Hairy Goldenrod. Rock Hill, Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
1909. *Solidago erecta* Pursh. Slender Goldenrod. Rock Hill, Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
1910. *Solidago uliginosa* Nutt. Bog Goldenrod. Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
1923. *Solidago ohioensis* Ridd. Ohio Goldenrod. Ira May Swamp, Wayne Twp., Pickaway Co.; North Union Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
1924. *Solidago riddellii* Frank. Riddell's Goldenrod. Ira May Swamp, Wayne Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
1930. *Sericocarpus linifolius* (L.) B. S. P. Narrow-leaf Whitetop Aster. Shawnee State Forest, Scioto Co. Conrad Roth.
1942. *Aster phlogifolius* Muhl. Thinleaf Purple Aster. Rock Hill, Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
1982. *Lacinaria scariosa* (L.) Hill. Large Blazing Star. "Red Hills Region," Central College, Franklin Co. R. B. Gordon and F. B. Chapman.
1983. *Lacinaria spicata* (L.) Ktz. Dense Blazing-star. North Union Twp., Ross Co.; Kibler's Bog, Circleville Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
1988. *Elephantopus carolinianus* Willd. Carolina Elephant's-foot. Crown City, Gallia Co. W. H. Camp.
1991. *Anthemis arvensis* L. Field Dog-fennel. Wapakoneta, Auglaize Co. Wm. Kayser.
1997. *Matricaria inodora* L. Scentless Camomile. "Several plants along railroad." Hillsboro, Highland Co. Katie M. Roads.
2006.1. *Artemisia absinthium* L. Common Wormwood. "Common escape in some sections of Twin Twp., Preble Co." From Europe. Lawrence E. Hicks.
2008. *Mesadenia reniformis* (Muhl.) Raf. Great Indian-plantain. Paint Creek Gorge, Ross Co. Floyd Bartley and Leslie L. Pontius. Also Mineral Springs, Adams Co. Specimen collected by W. A. Kellerman.
2010. *Mesadenia tuberosa* (Nutt.) Britt. North Union Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
2011. *Synosma suaveolens* (L.) Raf. Sweet-scented Indian-plantain. Wayne Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

2016. *Tussilago farfara* L. Coltsfoot. "A patch about five feet across, by the side of a road." Milan, Erie Co. S. Hawley. Ashtabula, Ashtabula Co. Also along Conneaut R. 6 miles from mouth. L. E. Hicks.

2023. *Cirsium virginianum* (L.) Mx. Virginia Thistle. Big Darby Creek, Franklin Co. E. S. Thomas.

2029.1. *Centaurea vochinensis* Bernh. Tyrol Star-thistle. Cantwell Cliffs, Hocking Co. Glenn W. Blaydes.

2029.2. *Centaurea nigra* L. Black Star-thistle. Beach City, Sugar Creek Twp., Stark Co. W. H. Camp.

2039.1. *Sonchus uliginosus* Bieb. Glandless Field Sow-thistle. Washington Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

2043. *Lactuca saligna* L. Willow Lettuce. Washington Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

2058. *Hieracium gronovii* L. Gronovius' Hawkweed. Springfield Twp., Lucas Co. Louis W. Campbell.

THE ALIMENTARY CANAL OF *PHYLLOPHAGA GRACILIS* BURM.*†

FRED WALKER FLETCHER.

INTRODUCTION.

The following study is a direct result of interest developed in a course of entomology given by Dr. C. H. Kennedy, on "Morphology and Development of Insects."

The material used in this work was collected in anticipation of such a study while the author was employed temporarily at the Asiatic Beetle Laboratory, at Westbury, Long Island, New York. The choice of *Phyllophaga gracilis*, Burm. for this problem was due to availability of specimens taken at a trap-light. This particular species is about one-half inch in length, elongate oblong in shape and pale brown in color. In the summer these beetles are found in Eastern Canada, Eastern and Southern United States, even extending as far west as Texas (5)‡. A considerable number of specimens was fixed in Kahle's solution after which they were transferred to and preserved in 70% alcohol.

The author acknowledges the helpful suggestions and criticisms of Dr. C. H. Kennedy under whose direction this study was made.

GROSS ANATOMY OF THE DIGESTIVE SYSTEM.

GENERAL DISCUSSION.

The alimentary canal is one and one-half times longer than the body, in correlation with the phytophagus habits of this beetle. Morphologically the alimentary canal is divisible into three primary regions according to their embryonic origin. The fore-intestine (Stomodaeum) arises as an anterior ectodermal invagination; the hind-intestine (Proctodaeum) arises as a similar posterior invagination; the mid-intestine (Mesenteron or Ventriculus) which connects the two, develops as an endodermal sac from a proliferation of rings of endodermal cells, one around the posterior end of the fore-intestine and the other around

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‡Numbers in parentheses refer to literature cited in bibliography at end of paper.

the anterior end of the hind-intestine (2). These primary regions with their differentiations may be tabulated as follows: (Fig. 1, Plate I).

Fore-intestine.	*Hind-intestine.*
1. Pharynx.	1. Pyloric valve.
2. Oesophagus.	2. Malpighian tubules.
3. Crop.	3. Proximal ileum.
4. Oesophageal valve.	4. Distal ileum.
	5. Colon.
Mid-intestine.	6. Rectum.
1. Stomach.	

GROSS STRUCTURES OF FORE-INTESTINE.

The fore-intestine is a rather short, slender tube which comprises a little over one-eighth of the total length of the entire canal. It extends from the mouth back to the beginning of the mesothorax.

The *pharynx*, the initial region of the alimentary canal just posterior to the mouth, is evident as a slight dilation of the tract in the head.

The *oesophagus* is a short narrow tube connecting the pharynx to the crop, lying in the most anterior part of the prothorax. The only essential difference between this region and the two it connects is size, the oesophagus being smallest. Like the pharynx, it has apparently no function other than conduction.

The *crop* is present as a dilation of the hinder portion of the oesophagus, but not being large and conspicuous in this insect, it is doubtful whether it functions as a food reservoir, as does a true crop. This portion of the canal lies entirely in the posterior part of the prothorax.

The *oesophagal valve* marks the separation between the fore- and mid-intestine by a constriction. This constriction may be found at the divison between the pro and mesothorax; functionally this valve serves to prevent regurgitation.

GROSS STRUCTURE OF MID-INTESTINE.

The stomach or mid-intestine comprises a little more than half the total length of the alimentary canal in this species of insect. It extends as a straight tube, nearly uniform in diameter, to the beginning of the abdomen where it curves a little to the left and then continues to the fourth abdominal segment. Here it curves abruptly to the right and extends back to the second abdominal segment. At this point it turns caudad and in the third abdominal segment makes a complete loop which lies underneath the preceding portion and terminates very abruptly at the pyloric valve.

Fundamentally the ventriculus has the power of secretion and of absorption.

GROSS STRUCTURES OF THE HIND-INTESTINE.

The hind-intestine occupies a little more than a fourth of the total length of the tract and is clearly differentiated into its various parts.

The *pyloric-valve*, located at the union of the mid-intestine with the hind-intestine, serves to close the posterior end of the stomach. It is recognizable as a slight constriction just antecedent to the Malpighian tubules.

The *Malpighian tubules* are attached to the canal just posterior to the pyloric valve and are four in number. Two of these tubules arise from a common opening, while the other two arise separately.

The *proximal ileum* is comparatively short and appears much the same as the mid-intestine. This portion of the canal is posterior to the Malpighian tubules and lies in the fourth abdominal segment.

The *distal ileum* is much the larger of the two parts of the ileum. In general outline it resembles a mammalian stomach and is the most conspicuous region of the hind-intestine. Its anterior margin is well defined as it arises abruptly from a constriction in the proximal ileum. Its caudal margin is likewise definitely narrowed where it joins the colon. The distal ileum normally lies in the body with the anterior end more caudad than the posterior one. As this region of the tract leaves the proximal ileum, it turns abruptly to the left and extends forward with the posterior end resting on the coiled part of the ventriculus. The wall of the distal ileum is quite transparent and internal papillate processes are visible from the exterior. Most of this part of the canal lies in the third and fourth abdominal segments. Its function is obscure.

The *colon* is a small tube linking the distal ileum with the rectum. As it arises from the distal ileum it takes a rather irregular path back to the rectum, with which it merges gradually. The colon is uniform in diameter throughout. Its function is mainly conduction.

The *rectum* is just an enlargement of the colon and lies in the fifth and sixth segments of the abdomen. Both circular and longitudinal muscles are evident on its surface. Like the colon its function is conduction.

Histological Structure of the Alimentary Canal.

HISTOLOGICAL STRUCTURE OF THE FORE-INTESTINE.

Histologically the fore-intestine reveals a similarity of make-up throughout its various parts. On examination the following tissues from within outwards can be demonstrated in its wall: (1) Intima of cuticula of chitin; (2) Epithelium of hypodermal cells; (3) Longitudinal muscles; (4) Circular muscles, and (5) "Peritoneal membrane" of connective tissue cells.

The innermost layer is the cuticula of chitin which is homologous with the cuticula of the body wall and is secreted by the hypodermal epithelium. This intima forms a rather thin, non-cellular, almost transparent layer which lines the entire fore-intestine (Figs. 2, 4 and 5, Plate I). In the region of the pharynx, however, it is thicker than in the other parts, being covered with small chitinous spines which project more or less caudad (Fig. 2, Plate I).

The epithelium of hypodermal cells which form the layer of tissue just outside the intima is composed of flattened irregular cells. Their cell-walls are usually quite evident although a basement membrane was not visible.

Immediately outside the epithelium may be found isolated bundles of longitudinal muscle tissue. A cross-section of the fore-intestine

demonstrates three such groups of muscles situated at the bases of folds in the epithelium.

Surrounding the longitudinal muscle layer is a more conspicuous layer of circular muscles, especially so around the anterior part of the pharynx and around the oesophagus. Elsewhere along the fore-intestine these muscles appear as scattered strands.

The outermost part of the fore-intestine has traces of connective tissue known as "peritoneal membrane." This consists of apparently structureless tissue in which an occasional nucleus makes its appearance.

At the point of junction of the fore- and hind-intestine, there is an *oesophageal valve* (Fig. 4, Plate I). This structure is formed by the wall of the fore-intestine being prolonged into the lumen of the mid-intestine. This projection of the fore-intestine then becomes reflected upon itself and passing forward unites with the stomach wall, (2). At this point the intima of the fore-intestine disappears. The epithelial cells of the inner part of this fold are much the same as those of the crop, being flattened and more or less irregular in shape.

The epithelial cells of the reflected area in the valve are much larger than those just mentioned and assume the shape of columnar epithelium.

The depression formed by the extension of the fore-intestine into the mid-intestine is filled with circular muscles. These are very numerous and serve to close the valve.

Just outside these muscles are ten or twelve strands of longitudinal muscles which extend from the epithelium of the fore-intestine across to the epithelium of the mid-intestine. Scattered between both ends of these muscles may be found numerous circular muscles. At this point the longitudinal and circular muscles reverse their positions in respect to each other, i.e. at the point where the mid-intestine originates, the longitudinal muscles shift to the outside of the circular muscles. The reverse is true in the fore-intestine. (See Fig. 4.)

The "peritoneal membrane" is present in this region.

HISTOLOGICAL STRUCTURES OF THE MID-INTESTINE.

The mid-intestine in *Phyllophaga gracilis* is an elongate tube which is marked anteriorly by the oesophageal valve, and posteriorly by the pyloric valve. This section of the canal is quite uniform in shape throughout, except that the posterior half is thrown into folds.

The structure of the mid-intestine is markedly different from that of the fore-intestine. In the ventriculus there is no intima; the relative positions of the circular and longitudinal muscles being reversed.

Histological examination of the stomach gives the following sequence of tissues: (1) epithelium of endoderm cells supported by a basement membrane. (2) circular muscles. (3) longitudinal muscles, and (4) "peritoneal membrane" of connective tissue. (Figs. 6 and 7, Plate I).

The cells of the entire epithelium vary greatly at times in size and shape; they may be almost cuboidal after a period of secretion; or they may be decidedly columnar during the resting stage, depending upon their physiological condition.

Secretion seems to be of the holocrine type, where the entire contents of the cell bursts out into the lumen of the intestine, after which the cell is replaced by new cells. In this particular insect these cells seem to be replaced either from nidi, (nests of embryonic tissue that lie below the epithelium) or from small replacement cells that rest on the basement membrane at the base of the epithelium. These cell nests are rather peculiar in that they lie completely below the epithelium, their definite relationship to digestion being as yet obscure. Further study may possibly reveal a condition similar to that found by Lewis in *Passalus cornutus*. The replacement cells already referred to are recognizable as small triangular shaped cells at the base of the epithelial layer. They present a varying degree of sizes, and in some sections, their function of replacement can hardly be doubted. It is hoped that further study will throw some light on these problems.

Surrounding these nidi and just outside the basement membrane may be found the circular muscle layer. This layer usually forms a rather conspicuous and continuous ring of tissue around the canal as viewed from a cross-section. (Fig. 6, Plate I). These muscle fibers are more or less interlaced at their ends.

Immediately outside the circular muscle layer are isolated strands of longitudinal muscles that are not nearly so abundant as the circular muscles.

A rather conspicuous amount of connective tissue is present in both the cross and longitudinal sections. (Fig. 7, Plate I).

HISTOLOGICAL STRUCTURES OF HIND-INTESTINE.

The hind-intestine which comprises a little more than one-fourth the total length of the alimentary tract, is differentiated considerably in its several parts. Anteriorly it is marked by the pyloric valve and posteriorly by the anus. Histologically this division of the canal presents from within outwards the following tissues: (1) intima; (2) Hypodermal epithelium resting on a basement membrane; (3) Circular muscles; (4) Longitudinal muscles, and (5) Connective tissue.

The *pyloric valve* represents the anterior limit of the hind-intestine. (Fig. 8, Plate II). The mid-intestine terminates abruptly and along the posterior margin of the columnar epithelium there is a row of small cuboidal cells. Immediately below this point of the tract there arises a ring of greatly elongated cells which extend down into the hind-intestine. This group of hypodermal cells is known as the pyloric valve.

The inner margin of the valve is lined with intima and makes its origin at the point of division between the mid- and hind-intestine.

The epithelium of the valve is bounded on the outside by well-developed circular muscles which function in closing the valve.

The basement membrane is indistinct.

The *Malpighian tubules* arise as invaginations of the hind-intestine just posterior to the pyloric valve. (Fig. 8, Plate II). The epithelial cells at origin of the tubules are rather narrow and elongate but they soon assume their characteristic cuboidal shape. The nuclei throughout the tubules are quite large ovate structures. Cross sections of the tubules show a decided difference in their sizes; number of epithelial

cells in such sections varying from five to fourteen or fifteen. (Figs. 9, 10 and 11, Plate II).

At the mouth of these tubules and extending into them for a short distance is a very delicate layer of intima. Elsewhere in them they are lined with a striated border. In some sections however this striated border is indistinct.

On the outside the Malpighian tubules are bounded by a narrow layer of connective tissue.

The *ileum* is the intial portion of the hind-intestine. It is bounded on the anterior side by the pyloric valve and on the posterior margin by the colon. In gross structure and histological make-up the ileum is divided into a proximal and distal region.

The *proximal division* of the ileum is shorter and narrower than the distal ileum and very thin walled. (Fig. 3, Plate I). The anterior margin gives rise to the Malpighian tubules which the posterior one is constricted where it joins the distal part of the ileum.

Internally the proximal ileum is lined with a very delicate layer of intima. Outside this layer of chitin is a layer of epithelium composed of very irregular cells which possess rather large ovoid nuclei. This layer of cells is thrown into numerous folds at each extremity of this portion of the ileum. The basement membrane is not visible.

The circular muscle layer is quite prominent and usually composed of two or three thin strands of muscle tissue.

Along the outside of this layer are scattered numerous isolated strands of longitudinal muscle tissue.

"Peritoneum" is also evident in some sections.

The *distal ileum* of *Phyllophaga gracilis* is without a doubt the most outstanding structure in the whole alimentary canal. It is unusual, both in its gross and histological anatomy. In size it is much larger than the proximal ileum, being over four times as long and twice as wide. The anterior margin of the distal ileum arises from a constriction at the posterior end of the proximal ileum. It at once expands to its normal size, having a diameter greater than that of any other part of the canal. Its caudal end narrows quite abruptly as it joins the colon but no indication of a valve is present at either end.

On examining this region microscopically, a very thin, delicate, almost transparent intima is found lining it throughout. The epithelium just outside possess cuboidal cells, except in some of the fold-like projections where they are more or less flattened and irregular in form.

The epithelium of the distal ileum is traversed by six longitudinal rows of papillate processes which extend into its lumen (Fig. 12, Plate II). The number of these projections per row vary according to their location on the ileal wall. Along the concave wall of this structure the protrusions vary in number from eight to ten, while on the opposite convex side, the variation is between twelve and sixteen. The total number of papilliform processes for the entire organ may vary from sixty to almost a hundred. These processes also vary considerably in size, those found in the middle portion of the distal ileum being much larger than those at each of its ends.

The intima enveloping these protrusions is covered with small spines which seem to aid in holding the cone-like mass of non-cellular

material which fits down over each one. (Fig 13, Plate II). This matrix assumes a deep blue color when stained with Delafield's Haemotoxylin. In it appear clear ovate objects which may be protozoa. A single median longitudinal section, seven micra in thickness, may contain nearly a hundred of these objects. It is possible that bacteria may produce this anomalous medium and that there might be a symbiotic relationship existing between protozoa and bacteria in this connection.

The circular layer of muscles surrounding the hypodermal epithelium of the distal ileum is quite well developed. Groups of them may be seen at the bases of small folds in the hypodermis in longitudinal sections. They are however found elsewhere as scattered strands beneath the epithelium.

The longitudinal muscles on the other hand are not as well developed and only an occasional strand is found.

Traces of "peritoneal membrane" are also present.

The *colon* is defined anteriorly by the distal ileum and posteriorly by the rectum, with which it gradually merges. The colon is a long slender tube with a diameter of about one-third that of the distal ileum.

The intima of this division of the tract is somewhat thicker than that in the ileum.

The epithelial cells of the colon are cuboidal in shape, possessing very large nuclei. A basement membrane is evident.

That side of the colon comparable to the concave side of the distal ileum is a short row of a dozen or so large spines which project caudad into the lumen of the colon. Also there are six large longitudinal folds in the epithelium of this region which are quite evident in cross-sections. (Fig. 14, Plate II).

The circular muscle layer of the colon is well developed and cross-sections of this part of the canal show a continuous band of them surrounding the epithelium.

The longitudinal muscles, however, are very poorly developed, only from two to four isolated groups being evident in a cross-section.

The *rectum* is very similar to the colon in make-up. The transition from one to the other takes place gradually. Externally the rectum is a dilation of the posterior end of the alimentary canal.

The intima and epithelium, as in the colon, are thrown into six large longitudinal folds and are known as rectal pads. The intima, however, is very thick, and in this respect, differs decidedly from the colon. The epithelial cells are of the cuboidal type and rest on a basement membrane that shows up more definitely here than in any other part of the canal.

The circular muscles are well-developed in this section of the alimentary tract, five of six layers of them being present.

The longitudinal muscles as in the rectum are few and inconspicuous. A small number of isolated groups comparable to those in the colon are present in cross-sections of this region. (Fig. 15, Plate II).

The "peritoneal membrane" of connective tissue appears much the same as it does in other divisions of the tract.

Conclusion.

The alimentary canal of *Phyllophaga gracilis* is of medium length, corresponding to its phytophagus habits. In correlation with other insects this canal is made up of three primary regions. The fore-intestine (Stomodaeum) and the hind-intestine (Proctodaeum) both ectodermal in origin and the mid-intestine (Mesenteron) which has an endodermal origin.

These three regions, however, are more or less specialized and differentiated, exhibiting the following modifications:

Fore-intestine:—Pharynx, oesophagus, crop and oesophageal valve.

Mid-intestine:—Entirely stomach.

Hind-intestine:—Pyloric valve, Malpighian tubules, proximal ileum, distal ileum, colon and rectum.

This study of the alimentary canal needs considerably more attention before a thorough understanding can be secured. The physiology of the digestive system should be worked out, in order to learn the exact relationships of the nidi and replacement cells, in this connection. The nidi afford considerable interest since they have in many cases broken not only through the basement membrane but also through the surrounding muscle layers. Such a study would be the best possible way to determine the type of secretion and absorption.

The condition existing in the distal ileum likewise requires an even more detailed study with fresh material, before a possible solution of its nature can be given. In this part of the ileum the papillate processes surrounded by an anomalous medium, filled with clear ovate objects resembling protozoa of the Microsporidian type present the most interesting situation in the whole alimentary canal of this beetle. It is hoped that further study will give a clue to the identity of these structures.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1. A dorsal view of the Alimentary Canal. Col.—colon; crop; D. Il.—Distal Ileum; Mal. T.—Malpighian Tubules; M. Int.—Mid-intestine; Oes.—Oesophagus; Oes. V.—Oesophageal valve; Ph.—Pharynx; P. Il.—Proximal Ileum; Py. V.—Pyloric valve; Rec.—Rectum.

Fig. 2. Cross-section through pharynx. C. Mus.—Circular Muscle; Epi.—Epithelium; Int.—Intima; L. Mus.—Longitudinal muscle; Sp.—Spine.

Fig. 3. Cross-section of Proximal ileum. Oil emersion drawing. C. Mus.—Circular muscle; Epi.—Epithelium; Int.—Intima; L. Mus.—Longitudinal Muscle.

Fig. 4. Longitudinal section through the oesophageal valve. C. Mus.—Circular Muscle; Epi.—Epithelium; Int.—Intima; L. Mus.—Longitudinal Muscle; Oes. V.—Oesophageal valve; P. mem.—"Peritoneal membrane."

Fig. 5. Cross-section through oesophagus. C. mus.—Circular muscle; Epi.—Epithelium; Int.—Intima; L. mus.—Longitudinal muscle.

Fig. 6. Cross-section of mid-intestine. C. mus.—Circular muscle; Epi.—Epithelium; F. T.—Fat tissue; L. mus.—Longitudinal muscle; Nidus; R. cell—Replacement cell.

Fig. 7. Longitudinal section through mid-intestine. C. mus.—Circular muscle; Epi.—Epithelium; F. T.—Fat tissue; L. mus.—Longitudinal muscle; Nidus.

Plate II.

Fig. 8. A longitudinal composite section through region of pyloric valve. C. mus.—Circular muscle; Epi.—Epithelium; Int.—Intima; Malp. Tub.—Malpighian Tubule; L. mus.—Longitudinal muscle; Py. valve—Pyloric valve.

Fig. 9. Cross-section through Malpighian tubule near extremity. Oil emersion drawing.

Fig. 10. A typical cross-section through a Malpighian tubule. Oil emersion drawing.

Fig. 11. Cross-section of Malpighian tubule near its origin. Oil emersion drawing. Epi.—Epithelium; P. mem.—"Peritoneal membrane" or connective tissue; St. B.—Striated border.

Fig. 12. Cross-section through distal ileum. Pap. Proc.—Papillate Process.

Fig. 13. Longitudinal section through distal ileum showing a papillate process. Oil emersion drawing. A. Med.—Anomalous medium; C. mus.—Circular muscle; Epi.—Epithelium; Int.—Intima; L. mus.—Longitudinal muscle; M. S.—Probably protozoa of the Microsporidian type; Sp.—Spine.

Fig. 14. Cross-section through the colon. C. mus.—Circular muscle; Epi.—Epithelium; Int.—Intima; L. mus.—Longitudinal muscle.

Fig. 15. Cross-section through the rectum. C. mus.—Circular muscle; Epi.—Epithelium; Int.—Intima; L. mus.—Longitudinal muscle.

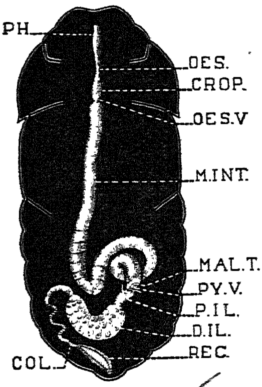

FIG.1.

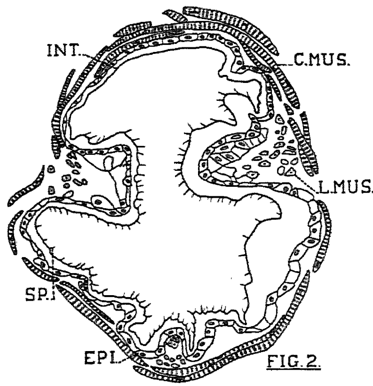

FIG.2.

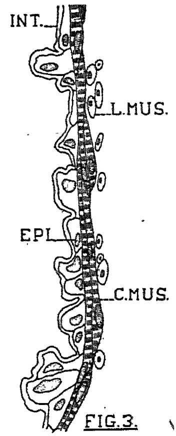

FIG.3.

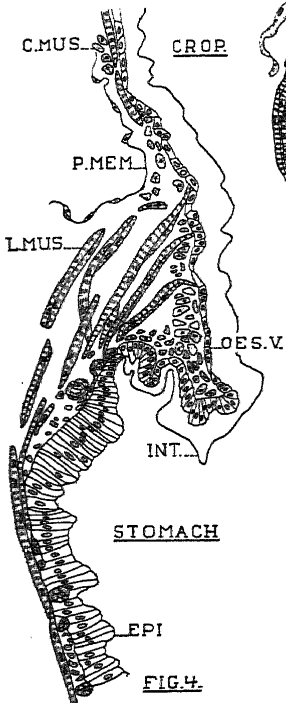

FIG.4.

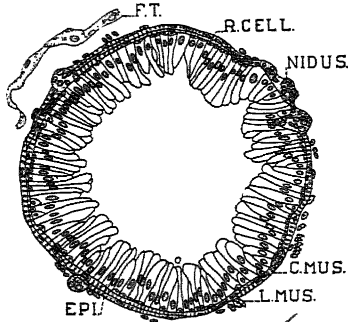

FIG 6.

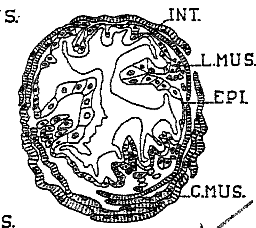

FIG.5.

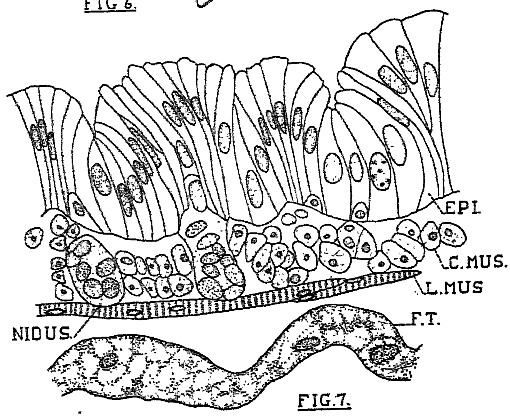

FIG.7.

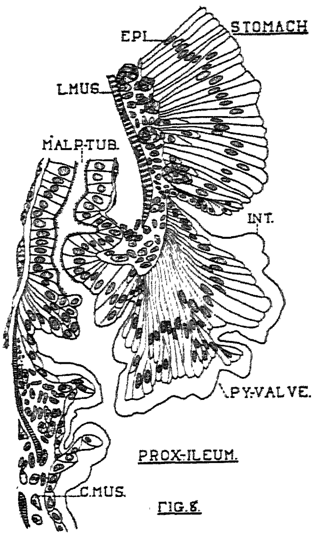

FIG. 8.

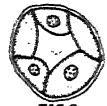

FIG. 9

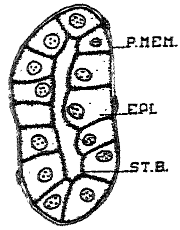

FIG. 11.

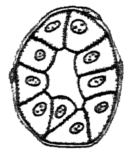

FIG. 10

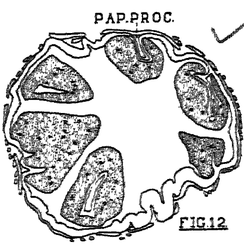

FIG. 12.

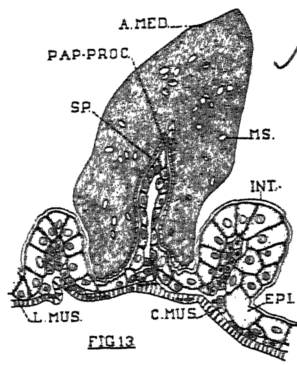

FIG. 13

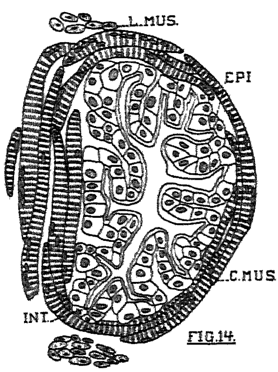

FIG. 14.

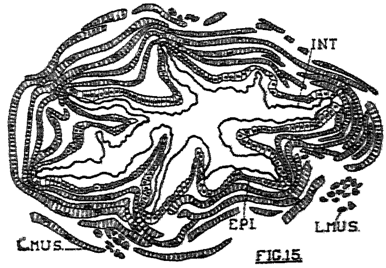

FIG. 15.

THE ALIMENTARY CANAL OF PHILAENUS LEUCOPHTHALMUS L.*

RODNEY CECIL,
U. S. Bureau of Entomology.

INTRODUCTION.

A study of the alimentary canal of *Philaenus leucophthalmus* L. was undertaken to determine the gross and histological structure of the tract and the source of the "spittle" with which the nymphs of this well known species of cercopid cover themselves.

This work was begun as a study in internal morphology, under the direction of Dr. C. H. Kennedy at the Ohio State University. Owing to the complexity of the alimentary canal, the work was not completed in the allotted time but has been continued as time permitted. The assistance and suggestions of Dr. Kennedy have been a great aid in the progress of the study.

METHODS.

Various methods of gross dissection were used at first without success. Serial sections were then prepared and drawings were made of each in an effort to reconstruct the complex diverticular region of the canal. Owing to the numerous loops and convolutions of the structures involved, this method also was unsuccessful. In fact, the completion of the study was almost despaired of until the following method for dissecting was discovered:

The specimen to be dissected was placed in a vial and given an anesthetic of ether or chloroform. As soon as the insect became quiet, it was removed from the vial to a dissecting dish which had a layer of blackened paraffin in the bottom. The specimen was then placed dorsal side up in normal position and its legs imbedded in the paraffin by melting the paraffin around them with a hot needle. When the paraffin cooled, the specimen was held securely by its legs. The insect was then covered with lukewarm normal saline solution. The usual method of gross dissection was followed with as much speed

*Contribution No. 100 from the Department of Zoology and Entomology, Ohio State University.

and caution as possible. The advantage of dissecting a live specimen lies in the transparency of live tissue. The convolutions of the stomach in the folds of the diverticula can be seen through the transparent covering of connective tissue on a living specimen. This can not be done on a dead specimen since dead tissue is opaque.

For the histological study the best sections were secured by the following method:

Nymphs and adults, collected just after molting, were killed by placing them in hot water at 70° C. for 3 minutes, fixed in Kahle's solution for 24 hours, and stored in 70 per cent alcohol. For study, after the usual preparation they were imbedded in paraffin, cut into sections 10 microns thick, mounted, and stained in hematoxylin and eosin.

Gross Anatomy of the Alimentary Canal.

The Cercopidæ secure their food by piercing the host plant with the modified mandibles and maxillæ, which rest in the grooved labium, and then pumping the liquid or sap up the tube from the rostrum by means of the pharynx.

The ducts of the salivary glands empty into the mouth cavity just anterior to the pharynx. There are two pairs of salivary glands which lie parallel to the oesophagus, (Fig. 1). One pair is above and laterad and the other ventrad and laterad of the oesophagus. The upper two are almost cylindrical whereas the lower two are club-shaped and taper posteriorly. Their length is approximately the same as that of the oesophagus. Each gland has a duct that leads anteriorly into the head where the duct of the lower gland fuses with the corresponding duct from the upper gland. The two ducts coil in the head region and then empty into the mouth cavity.

The pharynx is an enlargement of the fore intestine. It is slightly diamond shaped, is situated in the head posterior to the brain, and operates as a pump by means of numerous pharyngeal muscles. Food passes from the pharynx into the oesophagus.

The oesophagus is a long tube connecting the pharynx and oesophageal valve. It decreases in size posteriorly to the anterior region of the mesothorax, then enlarges slightly. This enlargement may indicate the remains of a crop. The oesophagus decreases in size in the metathoracic region, where the oesophageal valve is located. See Plate II, fig. 6.

The oesophageal valve is well developed structurally in this species and marks the division between the fore intestine and the mid-intestine. Before the first and second divisions of the stomach are "teased" apart the location of the oesophageal valve is often not apparent.

The mid-intestine begins at the oesophageal valve and ends at the point where the Malpighian tubes enter the canal. The anterior end of the mid-intestine is composed of two large pouch-like structures.

From a dorsal view, the first pouch or anterior diverticulum is located to the right and is slightly kidney shaped. Adjoining this pouch, slightly posteriorly and to the left, is a second pouch or posterior diverticulum of approximately the same size but less muscular.

The heavy walled anterior diverticulum retains its approximate position in a dead specimen, but the posterior diverticulum usually collapses and folds posteriorly, (Plate II, fig. 6). When the muscles and tissue connecting the two pouches are severed it is seen that the anterior and posterior diverticula are connected as shown in Plate I, Figure 2. The posterior diverticulum tapers posteriorly from the first to the second abdominal segments, then proceeds as a small, thin walled, light pink gut that continues ventrally and posteriorly to the 5th or 6th abdominal segment. The gut is constricted at this point and then immediately enlarges to twice its former size, (Figs. 1 and 13). Besides being of much larger size the gut is now yellow and opaque, and is full of irregular shaped objects. This yellow portion of the gut is easily seen through the semitransparent body wall of the nymph at the sixth or seventh segment. The gut continues to loop cross-wise of the body to the seventh abdominal segment; then turns and proceeds anteriorly, the yellow colored granules being present to about the third abdominal segment, where they gradually disappear. This condition exists in both nymphs and adults. As the granules decrease in number the gut assumes the same size and color as that portion which is anterior to the constriction. After many loops this portion of the stomach appears to enter the anterior diverticulum, at various points as shown in Plate I, Figures 2, 3, 4 and 5. The portion just described, with the constriction, has been described by Gadd (2)* as two blind caeca and the constriction given as the point where the two caeca had fused. This investigator was confused because the gut just described apparently entered the first pouch and because a second gut from this pouch proceeded to the anus. What became of the gut that entered the pouch and where the one leaving it came from was a mystery in this study until the method of gross dissection, previously described, was discovered.

The posterior portion of the mid-gut may also disappear under a fold of the wall of the posterior diverticulum as shown in Plate II, Figure 6, but is usually enfolded only by the anterior diverticulum as shown in the simplified diagrammatic drawings of Plate I, Figures 3, 4 and 5. The posterior mid-gut usually ascends in a fold of the diverticulum with few loops, to a point laterad of the oesophageal valve where the two pairs of Malpighian tubes are attached. There is an enlargement of the gut at this point which may be the location of a pyloric valve, though no valve was recognized in cross or longitudinal sections from this region. From this point the descending gut is the hind intestine.

The hind intestine extends from the point of attachment of the Malpighian tubules to the anus. The anterior portion makes several loops as it zigzags posteriorly in the fold of the wall of the anterior diverticulum before it appears at the posterior tip, (Plate I, Fig. 2).

*Number in parenthesis refers to Literature cited, page 127.

This intestine loops crosswise of the body and lies near the dorsal body wall, (Plate I, Fig. 1). The hind intestine is of uniform size to about the eighth abdominal segment, where it enlarges to form the rectum.

The Malpighian tubes are four in number and join the hind intestine as shown in Plate I, Figure 2.

The ascending anterior portions of the Malpighian tubes become small, thin-walled, and symmetrical just before they are enfolded by the anterior diverticulum and remain so to the point of attachment. Their posterior portions are relatively large, irregular in shape and have the appearance of a string of beads. This characteristic bead shape of the Malpighian tubes is due to the size and shape of the cells, (Plate II, Figure 16).

The Malpighian tubules lie next to the dorsal body wall and make crosswise loops similar to those of the descending hind intestine. They extend posteriorly to the seventh or eighth abdominal segment, and terminate with blind ends.

The rectum is a heavy walled, straight tube, that ends at the external anal opening, (Plate I, Fig. 1).

Histology of the Alimentary Canal.

The fore intestine from a histological point of view is not unusual. It is lined with a thin layer of chitin or intima which is extremely thin in the region of the oesophageal valve. The hypodermal cells of the oesophagus are well developed. In the anterior portion the cells have relatively large nuclei, are crowded, and assume a columnar shape. The cells of the middle to posterior portion of the oesophagus are cuboid in shape with rather elongated nuclei. In the oesophageal valve region the cells are much crowded, very long, with the nuclei as wide as the cell. (See Plate II, Fig. 6.)

The large salivary glands that are located parallel to the oesophagus have a peculiar cell structure. The upper pair have large cells with numerous irregular shaped lumens that are perhaps portions of connecting ducts, (Fig. 11). The lower pair of salivary glands is much larger than the upper pair and the cell arrangement gives them the appearance of rosettes. In cross section (Fig. 12) there is seen a common central duct with cells arranged around the duct. A chitinous lined duct results from the union of the ducts from the upper and lower glands, and this coils in the head region before entering the mouth.

The oesophageal valve is not formed by a folding of the fore intestine but by special elongated cells. This is unusual since an oesophageal value is usually formed by the fore intestine extending into the mid-intestine, then folding back upon itself, outward, to the anterior edge of the mid intestine. An oesophageal valve formed by elongated cells has the shape of one formed by a fold of the fore intestine and no doubt is just as efficient.

The mid-intestine or stomach is that part of the alimentary canal posterior to the oesophageal valve and anterior to the entrance of the Malpighian tubules. There is no cuticular covering of the digestive epithelium in the mid-intestine. The cells of the mid-intestine are

rather small and flattened in the region of the oesophageal valve, but posteriorly they become more columnar and irregular in size and shape. The first section of the stomach is unusual in that the portion lined with digestive epithelium is very small in relation to the size of the pouch. The capacity of this section of the stomach is reduced by crowding, caused by the folding of the stomach wall around portions of the hind-intestine and mid-intestine and Malpighian tubes. Plate II, Figure 6, shows a longitudinal section through the oesophagus, and anterior and posterior diverticula. This section shows that a large portion of the anterior diverticulum is occupied by the many loops of the Malpighian tubes and the mid-intestine and hind-intestine between folds of the diverticular wall. The posterior diverticulum shown in Figure 6 has also folded over a portion of the stomach and Malpighian tubes. This enclosing, by folding of the posterior diverticulum, occurs when these parts cross the diverticulum as shown in Plate I, Figure 1. The intestine and Malpighian tubes are not usually folded under by this section. It should be noted that the loops of the intestine and Malpighian tubes do not enter the stomach but are only under folds of the diverticular walls and are sealed over with connective tissue. This enfolding of the alimentary canal by the diverticulum is present in first-instar nymphs and evidently first occurs in the embyionic development.

The cells of the anterior diverticulum are large, irregular in size, and columnar in shape. The same type of cell continues throughout the stomach, but with variations in size. The largest epithelial cells occur in the posterior diverticulum and the smallest cells occur posterior to the stomach constriction. The constriction of the stomach shown in Plate I. Figure 1, and Plate II, Figure 13, located at the posterior end of the fifth abdominal segment is not a valve. Longitudinal and cross sections were made through the constriction in the stomach, and these failed to reveal any trace of a valve. (Fig. 13).

Posterior to the constriction the gut is always full of large yellow bodies that have the consistency of cheese. These bodies have large nuclei and in the cytoplasm are transparent particles. Kershaw (5) has dêscribed a similar body found in the alimentary canal of *Tomaspis saccharina* Dist., a cercopid. He had the contents of two nymphal posterior guts analyzed and reports the granules to be amorphous insoluble calcium phosphate and to constitute 80 per cent of the content of the gut.

The function of these yellow bodies in the alimentary canal is not known. Their color is undoubtedly due to bacteria, since four pure strains which produced yellow colonies on beef agar have been isolated on numerous occasions from smears taken from one of these macerated bodies. A further study is planned of the fauna of the alimentary canal of this spittle bug and this should give some interesting results.

The ascending portion of the gut in the folds of the anterior diverticulum is stomach to the point of entrance of the Malpighian tubes, (Plate I, fig 2). The large digestive epithelial cells disappear in the alimentary canal at this point, and the intestine posterior to this point is lined with chitin, which is definite proof that the division of stomach

and hind intestine has been reached. A slight enlargement at this point may indicate a pyloric valve, although no trace was found of one in sections from this region.

The cells of the rectum are relatively small and uniform throughout this portion of the canal, and there is very little variation in the thickness of the chitinous lining. (See Figures 13 and 14.)

Source of Spittle or Froth.

The source of the small white frothy masses noticed on many plants in the spring of the year has been explained in many and various ways. It was first written by Isidorous, cited by Gruner (3), in the sixth century that these white spittle masses were spit of the cuckoo bird and that small insects were spontaneously generated from it. It was also thought that certain plants secreted the spittle mass. According to Gruner (3), Bock in 1546 made a list of the plants that produced spittle. There are even sections of this country today where the people believe these spittle masses are the spit of snakes or cuckoos. These explanations of the source of the spittle, along with many other such theories, we know to be incorrect.

There are also several other more modern theories which have been advanced in explanation of the production of the spittle. It has been thought that the spittle is the production of salivary glands, or of special glands located in the abdomen, such as the Glands of Batelli, and the Malpighian tubules.

This study to determine the source of the spittle has consisted of field observations, laboratory experiments, and study of the histological structure.

The field observations on habits of the spittle-bug nymphs showed two things of interest; first, that all cercopid nymphs observed always elevate the posterior end of the abdomen, and, second, that they occasionally extend and retract the posterior segments in a telescoping fashion. This position of the abdomen is maintained at all times but the movement described takes place at short intervals when the nymph is covered with the clear fluid before bubbles are formed. These two habits are important in the formation of the spittle. A spittle-bug nymph removed from its covering of spittle to dry blotting paper will lose its external covering of fluid. When this nymph is replaced on a plant it soon locates a favorable spot for feeding, and inserts its beak into the plant tissue. Observation records show that the nymph moves its middle and posterior pairs of legs at intervals while feeding. This movement of the legs has been described by Guilbeau (4) as a means used by the nymph to mix the spittle as secreted. This habit of moving the legs when feeding is evidently not exclusively a function necessary to the production of spittle, since it has been observed as common to many Hemiptera and is not restricted to cercopids. The nymph increases in size as it feeds, and after feeding from 1 to 2 minutes it excretes a clear fluid from the anus. In from 5 to 12 minutes the nymph is completely covered with the fluid. The position of the tip of the abdomen when the fluid is excreted, causes the fluid to flood the dorsal surface of the abdomen and run off the sides of the body. When the

nymph is covered with clear fluid the tip of the abdomen is extended outside the fluid. While outside the fluid, the posterior lateral folds are opened to allow entry of air, then closed as the abdomen is retracted into the fluid. The body of the nymph is then contracted and a bubble of air is released into the fluid. This process is performed repeatedly until the clear fluid becomes a white frothy mass or spittle. In the method of forming the spittle I agree with Morse (7) but do not agree with him that the anal appendages serve as gills when the nymph is covered with spittle.

A study of the ventral external structure of the spittle-bug nymphs shows how air is taken and released. The sternal body wall is almost a flat surface, but the terga and pleura are greatly extended and when folded under the abdomen, meet and form a closed tube, or air space, for the entire length of the abdomen. It is evident that this tube is filled with air when the tip of the abdomen is thrust outside the fluid, and that when the abdomen is retracted under the fluid air is released and forms the bubbles. This air reservoir also has the function of transmitting air to the spiracles for use by the insect, since the spiracles are located in this region. The location of the spiracles and existence of the air reservoir explain how the nymphs breathe even though submerged in the spittle.

We have seen from observations that the clear fluid of which the spittle is formed is excreted at the anus.

The detailed histological study disproved several of the theories as to the source of the spittle. It is evident that the salivary glands do not directly secrete the fluid for the spittle, since the secretion from these glands is carried by ducts to the mouth. No special spittle glands were found in any part of the body of the species studied. The glands of Batelli (1) are described as being located on the seventh and eighth abdominal segments and to secrete a semi-solid material through the chitin of the seventh and eighth somites which is mixed with the excretion from the anus by use of the second and third pairs of legs to form the spittle. These glands or openings were not found in this study.

The theory that the anterior smooth portion of the Malpighian tubes secretes the fluid with which the spittle is formed can not be disproved at this time; however, this theory does not appear logical. The anterior smooth portion of the Malpighian tubes has very thin walls composed of small cells. This structure is not compatible with the fact that spittle bugs secrete a relatively large quantity of clear fluid in a short time. Also it has been proved experimentally that a spittle-bug nymph will die without forming spittle unless it can find a plant on which to feed. If the spittle were a secretion, the glands should possess enough stored fluid to produce at least a small quantity of spittle without feeding. This is not the case since many nymphs have been held under observation, and they have always fed for at least 1 minute before excreting any fluid. A nymph that is removed from a spittle mass and then replaced on a plant will enter the first spittle mass encountered, evidently seeking protection before food. A nymph placed on a semidry, cut plant is able to insert its proboscis, but owing to the dryness of the plant is unable to secure any sap. Under these

conditions a nymph does not excrete any fluid for spittle which would act as a protective covering. This indicates that the nymphs require food before any liquid is excreted for spittle. The fact that no special glands with anal openings were found in this study, and that other investigators have observed that the clear liquid is excreted at the anus, indicates that the clear fluid from which the spittle is formed is the normal excretion from the alimentary canal. The excretion would include secretions and excretions from the different cells and glands throughout the alimentary canal. It is evident that the quantity of excretion is determined by the rate of feeding or that the spittle-bug nymph is able to control the rate of flow of sap through the alimentary canal.

Licent (6) found by analysis that spittle consisted of 99.44 per cent water, 0.14 per cent organic matter, and 0.38 per cent inorganic material and that plant sap consisted of 94.57 per cent water, 3.83 per cent organic material, and 1.61 per cent inorganic material. The results of these analyses are additional proof that spittle is formed from excretion filled with air bubbles.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Diagrammatic dorsal view showing alimentary canal of nymph of *Philaenus leucophthalmus*.

Fig. 2. Simplified diagrammatic drawing showing ventral view of anterior and posterior diverticulum, showing route of gut and Malpighian tubes, enfolded by anterior diverticulum.

Figs. 3, 4 and 5. Diagrammatic drawing showing entry of stomach in folds of diverticulum.

PLATE II.

Fig. 6. Longitudinal section through oesophagus, oesophageal valve, anterior and posterior diverticula, showing by dotted line position of diverticula when expanded.

NOTE—Posterior diverticulum has enfolded a portion of stomach and Malpighian tubules.

Fig. 7. Cross-section through anterior and posterior diverticula before they join.

Fig. 8. Cross-section through anterior and posterior diverticula showing constriction where they join. This section is posterior to Figure 7.

Fig. 9. Cross-section through oesophagus.

Fig. 10. Cross-section through oesophagus posterior to Figure 9.

Fig. 11. Cross-section through upper salivary gland.

Fig. 12. Cross-section through lower salivary gland.

Fig. 13. Longitudinal section through stomach showing constriction and presence of yellow bodies posterior to constriction.

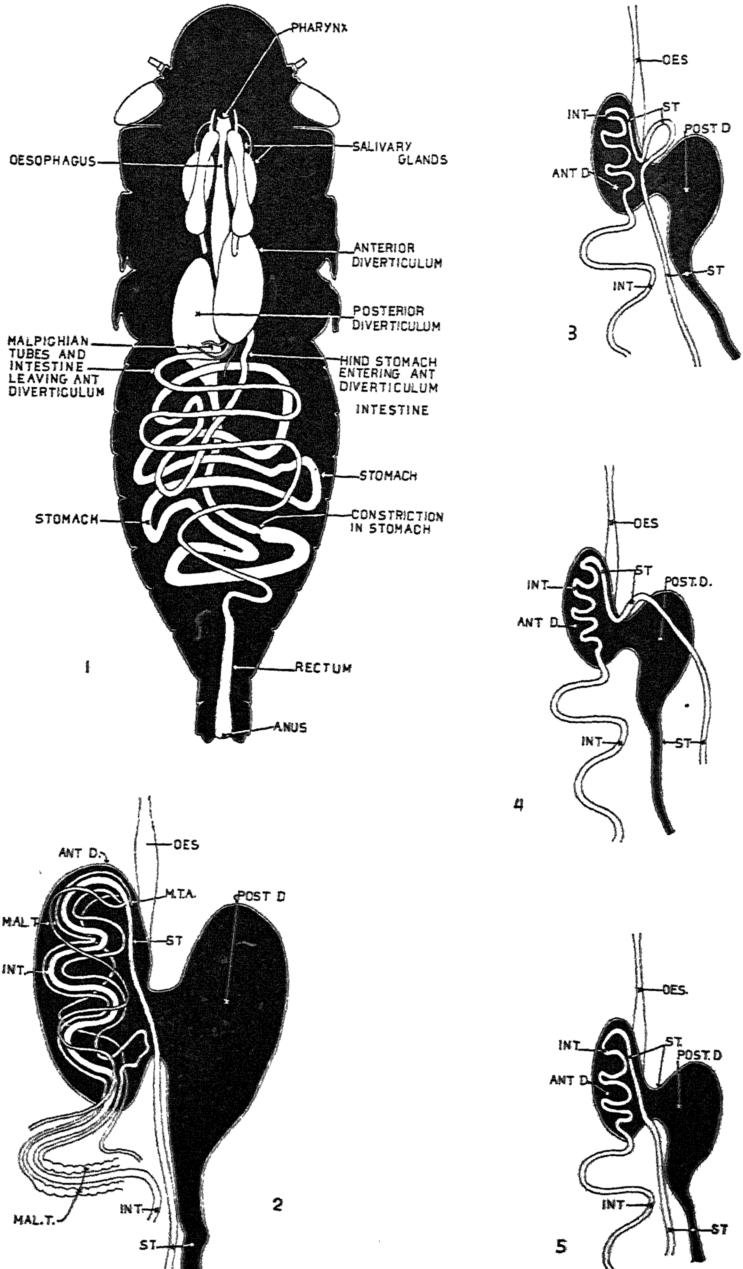
Fig. 14. Cross-section through rectum.

Fig. 15. Cross-section through rectum posterior to Figure 14.

Fig. 16. Cross and longitudinal section through beaded part of Malpighian tubule.

EXPLANATION OF ABBREVIATIONS.

Ant. D......Anterior diverticulum.
D. E........Diverticulum expanded.
Fat.........Fat tissue.
Int..........Intestine.
Mal. T......Malpighian tubes.
M. T. A.....Malpighian tubes attachment.
Oes.........Oesophagus.
Oes. V......Oesophageal valve.
Post D......Posterior diverticulum.
Post. D. E..Posterior diverticulum expanded.
St..........Stomach.


PHARYNX
SALIVARY GLANDS
OESOPHAGUS
ANTERIOR DIVERTICULUM
POSTERIOR DIVERTICULUM
MALPIGHIAN TUBES AND INTESTINE LEAVING ANT DIVERTICULUM
HIND STOMACH ENTERING ANT DIVERTICULUM
INTESTINE
STOMACH
STOMACH
CONSTRICTION IN STOMACH
RECTUM
ANUS
1
OES
INT
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POST D
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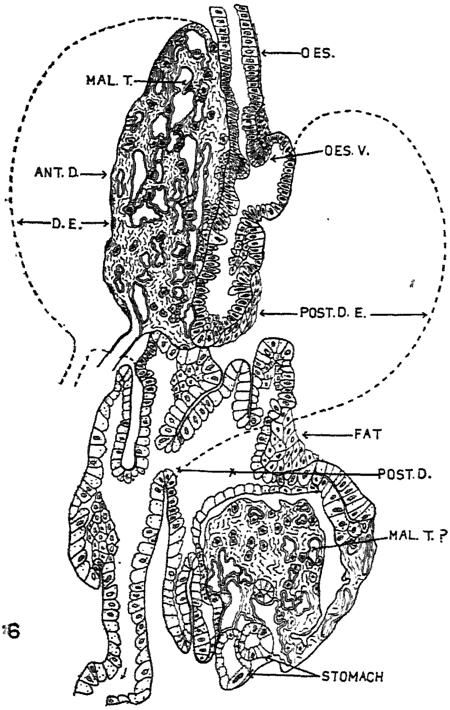

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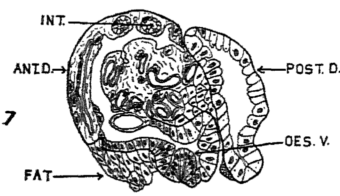

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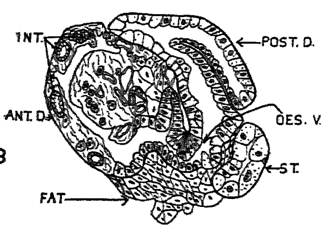

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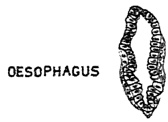

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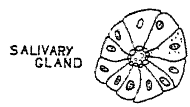

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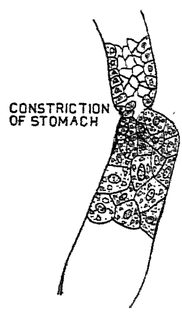

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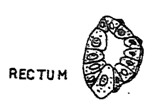

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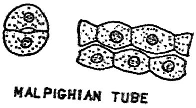

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PRELIMINARY REPORT OF THE ALGAE OF KENTUCKY.

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After spending a summer in the study of algae at the Franz Theodore Stone Laboratory of The Ohio State University, the writer began an algal survey of the State of Kentucky, under the direction of Dr. L. H. Tiffany, of that institution. This preliminary report is the result of an analysis of collections made during the period August 1, 1928, to June 11, 1929.

Very few, if any, forms of algae have ever been reported from Kentucky. Perhaps algae are as numerous, grow as abundantly, and are as easily collected in Kentucky as in any inland state. Heretofore the men of Kentucky who were interested in the study of algae were not sufficiently interested to make a survey or report of any kind concerning these plants. It is hoped that this preliminary report will be followed by others on the algal flora of the state.

Most of the collections were made in two distinct regions of the state. The first is the Blue Grass Region, where the geological formation is Ordovician and where different bodies of water range from neutral to slightly alkaline (pH 8.4 perhaps being about the highest). The second region is Hart County and some of the adjoining counties. This region has a different soil formation, being the Mississippian. Here the water is slightly acid. In this region the number of collections was very small, but a great many forms of algae were found, especially Desmids. It is thought that when collections can be made at other times of the year and in other parts of the state that many other forms can be added to the list because of the periodicity of the various forms of algae, the types of soil formation and the differences in the reaction of the water.

Several persons have assisted me in this work by sending or bringing collections from their respective communities. The samples were preserved in Transeau's solution, made with 6 parts water, 3 parts alcohol, and 1 part formalin.

Of the 120 counties in the state, only 21 are represented in this report, and only 2 of these are represented by more than

100 forms of algae, and only 6 by more than 10 forms. The highest ranking counties with the number of forms in each are Fayette, 239; Hart, 130; Jessamine, 47; Clark, 29; Larue, 21, and Barren, 17. Of the 373 forms in this report, 263 have been found in only one county, while each of the other 110 have been found in two or more counties.

The genera and species of this report are listed alphabetically under each family represented.

MYXOPHYCEÆ CHROOCOCCEÆ.

CHROOCOCCALES.

Chroococcaceæ.

Aphanocapsa biformis A. Braun. Fayette Co. **A. grevillei** (Hassall) Rabenhorst. Fayette Co.

Aphanothece stagnina (Sprengel) A. Braun. Fayette Co.

Chroococcus decorticans A. Braun. Fayette Co. **C. minutus** (Kützing) Nâgeli. Fayette Co. **C. turgidus** (Kützing) Nägeli. Fayette Co.

Coelosphaerium dubium Grunow. Fayette Co. **C. kuetzingianum** Nägeli. Fayette Co. **C. naegelianum** Unger. Fayette Co., Hart Co., Jessamine Co.

Gloeocapsa gigas W. & G. S. West. Nelson Co.

Gomphosphaeria aponina Kützing. Hart Co. **G. lacustris** Chodat. Hart Co.

Merismopedia convoluta Brebisson. Carroll Co., Fayette Co., Garrard Co., Hart Co., Hickman Co. **M. glauca** (Ehrenberg) Nägeli. Fayette Co. var. **fontinale** Hansgirg. Hart Co. **M. punctata** Meyen. Barren Co. **M. tenuissima** Lemmermann. Fayette Co.

Microcystis aeruginosa Kützing. Fayette Co. var. **major** (Wittrock) G. M. Smith. Fayette Co., Jessamine Co. **M. flos-aquae** (Wittrock) Kirchner. Fayette Co. **M. marginata** (Meneghini) Kützing. Fayette Co.

HORMOGONEÆ.

HORMOGONEALES.

Oscillatoriaceæ.

Lyngbya aestuarii (Mertens) Liebmann. Barren Co., Hart Co., Jefferson Co. **L. birgei** G. M. Smith. Fayette Co. **L. major** Meneghini. Fayette Co., Hart Co. **L. martensiana** Meneghini. Fayette Co. **L. spirulinoides** Gomont. Fayette Co.

Microcoleus vaginatus (Vaucher) Gomont. Fayette Co.

Oscillatoria amphibia Agardh. Barren Co., Fayette Co. **O. annæ** van Goor. Hart Co. **O. chlorina** Kützing. Fayette Co. **O. formosa** Bory. Fayette Co., Jessamine Co. **O. jenensis** G. Schmid. Hart Co. **O. limosa** Kützing. Fayette Co., Hart Co. **O.**

minnesotensis Tilden. Fayette Co. **O. ornata** Kützing. Fayette Co. **O. princeps** Vaucher. Barren Co., Clark Co., Fayette Co., Hart Co., Hickman Co., Wolfe Co. **O. sancta** Kützing. Fayette Co., Wolfe Co. **O. splendida** Greville. Fayette Co., Rowan Co. **O. subtilissima** Kützing. Fayette Co. **O. tenuis** C. A. Agardh. Campbell Co., Fayette Co.

Phormidium ambiguum Gomont. Fayette Co. **P. autumnale** (Agardh.) Gomont. Fayette Co. **P. laminosum** (Agardh) Gomont. Fayette Co. **P. retzii** (Agardh) Gomont. Fayette Co. **P. uncinatum** (Agardh) Gomont. Fayette Co., Wayne Co.

Spirulina nordstedtii Gomont. Wayne Co.

Nostocaceæ.

Anabaena affinis Lemmermann. Fayette Co., Hart Co. **A. hallensis** (Janczewski) Bornet & Flahault. Fayette Co. **A. macrospora** var. **robusta** Lemmermann. Fayette Co. **A. planctonica** Brunnthaler. Fayette Co. **A. spiroides** Klebahn. Fayette Co., Hart Co. var. **contracta** Klebahn. Fayette Co. **A. torulosa** (Carm.) Lagerheim. Fayette Co.

Aphanizomenon flos-aquae (L.) Ralfs. Fayette Co.

Cylindrospermum alatosporum Fritsch. Fayette Co. **C. catenatum** Ralfs. Fayette Co. **C. lichenforme** (Bory) Kützing. Fayette Co. **C. muscicola** Kützing. Fayette Co.

Nodularia harveyana (Thwaites) Thuret. Clark Co., Fayette Co., Jessamine Co.

Nostoc comminutum Kützing. Fayette Co. **N. commune** Vaucher. Fayette Co. **N. microscopicum** Carmichael. Fayette Co. **N. muscorum** Kützing. Fayette Co. **N. piscinale** Kützing. Fayette Co.., Jessamine Co.

Scytonemataceæ.

Scytonema intertextum (Kützing) Rabenhorst. Fayette Co.

Rivulariaceæ.

Calothrix fusca (Kützing) Bornet & Flahault. Fayette Co.

Gloeotrichia echinulata (J. E. Smith) Richter. Hart Co.

CHRYSOPHYCEÆ.

OCHROMONADALES.

Ochromonadaceæ.

Dinobryon setularia Ehrenberg. Rowan Co.

RHODOPHYCEÆ FLORIDEÆ.

NEMALIONALES.

Lemaneaceæ.

Lemanea torulosa (Roth) Agardh. Fayette Co.

HETEROKONTEÆ.

HETEROTRICHALES.

Tribonemaceæ.

Tribonema bombycina (Agardh) Derbes & Solier. Fayette Co., Larue Co., Rowan Co. forma **tenue** Hazen. Fayette Co. **T. raciborskii** Heering. Fayette Co. **T. utriculosa** Kutzing. Fayette Co.

HETEROSIPHONALES.

Botrydiaceæ.

Botrydium granulatum (L.) Greville. Fayette Co.

CHLOROPHYCEÆ ISOKONTÆ.

VOLVOCALES.

Chlamydomonadaceæ.

Chlamydomonas snowii Printz. Fayette Co.

Volvocaceæ.

Eudorina elegans Ehrenberg. Clark Co., Fayette Co., Jessamine Co., Scott Co.

Gonium pectorale Muller. Fayette Co.

Pandorina morum Bory. Clark Co., Fayette Co., Hart Co., Jessamine Co.

Pleodorina californica Shaw. Clark Co., Fayette Co., Hart Co., Jessamine Co. **P. illinoisensis** Kofoid. Fayette Co.

Volvox aureus Ehrenberg. Hart Co. **V. mononæ** G. M. Smith. Clark Co.

CHLOROCOCCALES.

Palmellaceæ.

Gloeocystis gigas (Kützing) Lagerheim. Fayette Co.

Planctosphaeria gelatinosa G. M. Smith. Fayette Co.

Sphaerocystis schroeteri Chodat. Fayette Co.

Tetraspora gelatinosa (Vaucher) Desvaux. Clark Co., Fayette Co., Scott Co. **T. lacustris** Lemmermann. Fayette Co. **T. lubrica** (Roth) Agardh. Fayette Co.

Hydrodictyaceæ.

Hydrodictyon reticulatum (L.) Lagerheim. Clark Co., Fayette Co., Jessamine Co., Washington Co.

Pediastrum biradiatum Meyen. Fayette Co. **P. boryanum** (Turpin) Meneghini. Fayette Co., Jessamine Co. **P. duplex** Meyen. Fayette Co., Hart Co. var. **clathratum** (A. Braun) Lagerheim. Fayette Co. var. **cohaerens** Bohlin. Fayette Co. var. **gracillimum** W. & G. S. West. Fayette Co. var. **reticulatum** Lagerheim.

Fayette Co. **P. kawraiskyi** Schmidle. Fayette Co. **P. ovatum** (Ehrenberg) A. Braun. Fayette Co. **P. simplex** var. **duodenarium** (Bailey) Rabenhorst. Fayette Co., Hart Co., Hickman Co., Jessamine Co., Larue Co. **P. sturmii** Reinsch. Fayette Co. **P. tetras** (Ehrenberg) Ralfs. Clark Co., Fayette Co., Hart Co. var. **tetraodon** (Corda) Hansgirg. Barren Co., Clark Co., Fayette Co., Hart Co.

Chlorococcaceæ.

Characium limneticum Lemmermann. Fayette Co., Garrard Co. **C. stipitatum** (Bachmann) Wille. Fayette Co.

Chlorococcum infusionum (Schrank) Meneghini. Fayette Co.

Dictyosphaeriaceæ.

Dictyosphaerium ehrenbergianum Nägeli. Fayette Co. **D. pulchellum** Wood. Fayette Co., Hart Co.

Dimorphococcus lunatus A. Braun. Hart Co.

Autosporaceæ.

Actinastrum gracillimum G. M. Smith. Fayette Co., Garrard Co. **A. hantzschi** Lagerheim. Fayette Co., Hart Co.

Ankistrodesmus falcatus (Corda) Ralfs. Hart Co. var. **mirabilis** (W. & G. S. West) G. S. West. Fayette Co., Garrard Co., Jessamine Co. var. **tumidus** (W. & G. S. West) G. S. West. Fayette Co.

Closteriopsis longissima Lemmermann. Fayette Co.

Coelastrum cambricum Archer. Fayette Co. **C. microporum** Nägeli. Clark Co., Fayette Co., Hart Co.

Crucigenia crucifera (Wolle) Collins. Fayette Co. **C. fenestrata** Schmidle. Fayette Co. **C. quadrata** Morren. Bourbon Co., Fayette Co. **C. rectangularis** (Nägeli) Gay. Fayette Co. **C. tetrapedia** (Kirchner) W. & G. S. West. Fayette Co. **C. truncata** G. M. Smith. Hart Co.

Errerella bornheimensis Conrad. Fayette Co.

Gloeotaenium loitlesbergerianum Hansgirg. Clark Co.

Golenkinia paucispina W. & G. S. West. Hart Co. **G. radiata** Chodat. Fayette Co.

Kirchneriella contorta (Schmidle) Bohlin. Fayette Co. **K. lunaris** var. **irregularis** G. M. Smith. Fayette Co. **K. obesa** (W. West) Schmidle. Fayette Co. var. **major** (Bernard) G. M. Smith. Fayette Co.

Lagerheimia droescheri (Lemmermann) Printz. Fayette Co. **L. longiseta** (Lemmermann) Printz. Fayette Co. **L. subsalsa** Lemmermann. Fayette Co.

Micractinium pusillum Fresenius. Fayette Co. var. **elegans** G. M. Smith. Fayette Co.

Nephrocytium lunatum W. West. Hart Co.

Oocystis borgei Snow. Fayette Co. **O. elliptica** W. West. Clark Co., Jessamine Co., Nelson Co. **O. lacustris** Chodat. Fayette Co. **O. parva** W. & G. S. West. Fayette Co.

Quadrigula lacustris (Chodat) G. M. Smith. Jessamine Co.

Scenedesmus abundans (Kirchner) Chodat. Fayette Co. var. **brevicauda** G. M. Smith. Fayette Co. var. **longicauda** G. M. Smith. Fayette Co. **S. acuminatus** (Lagerheim) Chodat. Fayette Co. **S. acutiformis** Schröder. Barren Co., Clark Co., Fayette Co. **S. arcuatus** var. **platydisca** G. M. Smith. Fayette Co. **S. armatus** (Chodat) G. M. Smith. Fayette Co. **S. bernardii** G. M. Smith. Fayette Co. **S. bijuga** (Turpin) Lagerheim. Fayette Co., Hart Co., Jessamine Co. var. **alternans** (Reinsch) Borge. Fayette Co. **S. brasiliensis** Bohlin. Fayette Co. **S. denticulatus** Lagerheim. Fayette Co. **S. dimorphus** (Turpin) Kützing. Fayette Co., Jessamine Co. **S. obliquus** (Turpin) Kützing. Fayette Co., Jessamine Co. **S. opoliensis** P. Richter. Fayette Co., Hart Co. **S. quadricauda** (Turpin) Brebisson. Fayette Co., Hart Co. var. **longispina** (Chodat) G. M. Smith. Fayette Co. var. **parvus** G. M. Smith. Fayette Co. var. **quadrispina** (Chodat) G. M. Smith. Fayette Co., Jessamine Co. var. **westii** G. M. Smith. Fayette Co., Garrard Co.

Schroederia setigera (Schröder) Lemmermann. Fayette Co.

Selenastrum gracile Reinsch. Hart Co. **S. minutum** (Nägeli) Collins. Fayette Co. **S. westii** G. M. Smith. Fayette Co.

Sorastrum spinulosum Nägeli. Clark Co., Fayette Co.

Tetraedron enorme (Ralfs) Hansgirg. Clark Co. **T. limneticum** Borge. Fayette Co. **T. minimum** (A. Braun) Hansgirg. Fayette Co., Garrard Co., Hart Co. **T. pentaedricum** W. & G. S. West. Fayette Co. **T. planctonicum** G. M. Smith. Fayette Co., Hart Co. **T. regulare** Kützing. Fayette Co., Hart Co., Jessamine Co. var. **incus** Teiling. Hart Co. **T. trigonum** (Nägeli) Hansgirg. Fayette Co., Hart Co. var. **gracile** (Reinsch) de Toni. Fayette Co.

Trochiscia aspera (Reinsch) Hansgirg. Fayette Co.

ULOTRICHALES.

Ulotrichaceæ.

Ulothrix tenerrima Kützing. Fayette Co. **U. variabilis** Kützing. Fayette Co.

Cylindrocapsa geminella Wolle. Clark Co., Fayette Co.

Pleurococcaceæ.

Pleurococcus vulgaris Meneghini. Fayette Co.

Chaetophoraceæ.

Chaetophora elegans (Roth) Agardh. Hickman Co.

Draparnaldia acuta (Agardh) Kützing. Pike Co. **D. glomerata** (Vaucher) Agardh. Hickman Co.

Stigeoclonium stagnatile (Hazen) Collins. Fayette Co. **S. subsecundum** Kützing. Garrard Co. **S. tenue** (Agardh) Kützing. Fayette Co.

Coleochaetaceæ.

Coleochaete scutata Brebisson. Fayette Co.

Trentepohliaceæ.

Trentepohlia aurea (L.) Martius. Larue Co.

SIPHONOCLADIALES.

Cladophoraceæ.

Cladophora crispata (Roth) Kützing. Jessamine Co. **C. fracta** (Dillw.) Kützing. Fayette Co. **C. glomerata** (L.) Kützing. Barren Co., Jessamine Co., Nelson Co. **C. kuetzingiana** Grunow. Garrard Co. **C. uberrima** Lambert. Washington Co.

Pithophora varia Wille. Clark Co., Fayette Co., Jessamine Co.

Rhizoclonium crassipellitum var. **robustum** G. S. West. Fayette Co. **R. crispum** Kützing. Fayette Co. **R. hieroglyphicum** (Agardh) Kutzing. Bourbon Co., Clark Co., Fayette Co., Washington Co.

SIPHONALES.

Vaucheriaceæ.

Vaucheria geminata (Vaucher) de Candolle. Fayette Co., Pike Co., Scott Co. **V. hamata** (Vaucher) de Candolle. Fayette Co. **V. repens** Hassall. Fayette Co. **V. uncinata** Kützing. Carroll Co., Fayette Co.

STEPHANOKONTÆ.

OEDOGONIALES.

Oedogoniaceæ.

Bulbochaete insignis Pringsheim. Hart Co.

Oedogonium cardiacum var. **minus** Lemmermann. Fayette Co. **O. crassiusculum** var. **arechavaletae** (Wittrock) Hirn. Hardin Co. var. **idioandrosporum** Nordstedt & Wittrock. Hart Co. **O. crenulatocostatum** Wittrock. Hickman Co. **O. crispum** var. **gracilescens** Wittrock. Hart Co. **O. gallicum** Hirn. Hart Co. **O. gracillimum** Wittrock & Lund. Hart Co. **O. hirnii** Gutwinski. Hart Co., Hickman Co. **O. illinoisense** Transeau. Hart Co. **O. intermedium** Wittrock. Hart Co. **O. iowense** Tiffany. Hart Co. **O. latiusculum** Tiffany. Clark Co. **O. lautumniarum** Wittrock. Fayette Co. **O. multisporum** Wood. Harrison Co. **O. pachyandrium** Wittrock. Hart Co. **O. plagiostomum** var. **gracilius** Wittrock. Fayette Co., Hart Co. **O. sexangulare** Cleve. Hart Co.

AKONTÆ.

ZYGNEMALES.

Zygnemaceæ.

Debarya decussata Transeau. Barren Co.

Mougeotia sphaerocarpa Wolle. Hart Co.

Spirogyra affinis (Hassall) Petit. Fayette Co. **S. communis** (Hassall) Kützing. Fayette Co., Hart Co. **S. condensata** (Vaucher) Kützing. Fayette Co., Jessamine Co. **S. decimina** (Muller) Kützing. Fayette Co. var. **crassior** Gutwinski. Fayette Co. var. **inflata** Fritsch. Fayette Co. var. **plena** W. & G. S. West. Fayette Co. var. **triplicata** Collins. Fayette Co. **S. farlowii** Transeau. Fayette Co. **S. juergensii** Kützing. Fayette Co., Hardin Co., Hart Co., Jessamine Co., Larue Co. **S. lagerheimii** Wittrock. Clark Co. **S. longata** (Vaucher) Kützing. Fayette Co., Jessamine Co., Scott Co. **S. nitida** (Dillwyn) Link. Clark Co., Fayette Co. **S. porticalis** (Muller) Cleve. Fayette Co. **S. protecta** Wood. Jessamine Co. **S. punctata** Cleve. Hart Co. **S. quadrata** (Hassall) Petit. Fayette Co. var. **bifaciata** Kirchner. Clark Co. **S. rivularis** (Hassall) Rabenhorst. Larue Co. **S. singularis** Nordstedt. Harrison Co., Washington Co. **S. stictica** (Eng. bot.) Wille. Jefferson Co. **S. varians** (Hassall) Kutzing. Fayette Co., Jessamine Co. var. **minor** Teodoresce. Clark Co., Fayette Co. var. **scrobiculata** Stockmayer. Clark Co., Fayette Co. **S. velata** var. **occidentalis** Transeau. Carroll Co., Fayette Co. **S. weberi** Kützing. Jefferson Co., Jessamine Co.

Zygnema insignis (Hassall) Kützing. Carroll Co. **Z. stellinum** (Vaucher) Agardh. Carroll Co., Fayette Co.

DESMIDIALES.

Mesotaeniaceæ.

Netrium digitus (Ehrenberg) Itzingsohn & Rothe. Barren Co.

Desmidiaceæ.

Arthrodesmus subulatus var. **subaequalis** W. & G. S. West. Hart Co.

Closterium acerosum (Schrank) Ehrenberg. Fayette Co., Jessamine Co., Larue Co. var. **elongatum** Brebisson. Fayette Co. **C. calosporum** Wittrock. Fayette Co. **C. cynthia** De Not. Jessamine Co. **C. dianæ** Ehrenberg. Fayette Co. **C. didymotocum** Corda. Campbell Co., Hart Co. **C. ehrenbergii** Meneghini. Clark Co., Fayette Co., Hart Co., Jessamine Co., Larue Co. **C. gracile** Brebisson. Fayette Co. **C. intermedium** Ralfs. Campbell Co. **C. juncidum** Ralfs. Hart Co. var. **brevior** Roy. Hart Co. **C. lanceolatum** Kützing. Bourban Co. **C. leibleinii** Kutzing. Fayette Co., Garrard Co., Hart Co., Jessamine Co., Nelson Co. **C. lineatum** Ehrenberg. Hart Co., Jessamine Co. **C. lunula** (Muller) Nitzsch. Fayette Co., Jessamine Co. **C. macilentum** Brebisson. Hart Co. **C. moniliferum** (Bory) Ehrenberg. Bourban

Co., Fayette Co., Hart Co., Jessamine Co. **C. parvulum** Nageli. Barren Co. **C. peracerosum** Gay. Fayette Co. **C. praelongum** Brebisson. Fayette Co. **C. pritchardianum** Archer. Fayette Co., Hart Co., Jessamine Co., Wolfe Co. **C. ralfsii** var. **hybridum** Rabenhorst. Pike Co. **C. regulare** Brebisson. Hart Co. **C. rostratum** Ehrenberg. Hart Co. **C. strigosum** Brebisson. Larue Co. **C. striolatum** Ehrenberg. Hart Co. **C. subulatum** (Kutzing) Brebisson. Hart Co. **C. venus** Kützing. Fayette Co., Hart Co.

Cosmarium biretum Brebisson. Fayette Co., Hardin Co., Harrison Co., Jessamine Co., Larue Co. **C. botrytis** var. **gemmiferum** (Brebisson) Nordstedt. Fayette Co. var. **mediolaeve** West. Fayette Co. **C. broomei** Thwaites. Hart Co., Jessamine Co., Washington Co. **C. calcareum** Wittrock. Fayette Co. **C. commissurale** Brebisson. Hart Co. **C. contractum** Kirchner. Fayette Co., Hart Co. **C. cucumis** (Corda) Ralfs. Fayette Co. **C. fastidiosum** W. & G. S. West. Fayette Co. **C. formulosum** Hoff. Fayette Co. var. **nathorstii** (Boldt) W. & G. S. West. Jessamine Co. **C. granatum** Brebisson. Barren Co., Fayette Co., Hart Co., Jessamine Co., Washington Co. **C. isthmochondrum** Norstedt. Fayette Co. **C. laeve** Rabenhorst. Clark Co., Fayette Co. **C. margaritatum** (Lundell) Roy & Bliss. Hart Co. **C. meneghinii** Brebisson. Fayette Co. **C. nagelianum** Brebisson. Fayette Co. **C. obtusatum** Schmidle. Barren Co., Hart Co., Larue Co., Washington Co. var. **beanlandii** W. & G. S. West. Jessamine Co. **C. ochthodes** Nordstedt. Hart Co., Larue Co. **C. orthostichum** var. **compactum** W. & G. S. West. Fayette Co. **C. ovale** Ralfs. Hart Co. **C. portianum** Archer. Barren Co., Hart Co. var. **nephroideum** Wittrock. Hart Co. **C. pseudobroomei** Wolle. Hart Co. **C. pseudoconnatum** var. **ellipsoideum** W. & G. S. West. Hart Co. **C. pygmaeum** Archer. Clark Co., Hart Co., Larue Co. **C. pyramidatum** Brebisson. Hart Co. **C. quadrum** Lundell. Hart Co. **C. regnelli** Wille. Fayette Co., Jessamine Co. **C. reniforme** (Ralfs) Archer. Bourban Co., Carroll Co., Fayette Co., Jessamine Co., Larue Co. var. **apertum** W. & G. S. West. Clark Co., Fayette Co., Hart Co., Jessamine Co., Washington Co. **C. sexnotatum** var. **tristriatum** (Lutkem) Schmidle. Clark Co. **C. subcrenatum** Hantzsch. Jessamine Co., Washington Co. **C. subnotabile** Wille. Fayette Co. **C. subreniforme** Nordstedt. Hart Co. **C. succisum** West. Hart Co. **C. taxichondrum** Lundell. Hart Co. **C. tetraophthalmum** Brebisson. Hart Co. **C. turpinii** Brebisson. Bourban Co., Carroll Co., Fayette Co., Harrison Co., Hart Co., Jessamine Co., Larue Co., Washington Co. var. **eximium** W. & G. S. West. Barren Co. **C. ungerianum** var. **subtriplicatum** W. & G. S. West. Larue Co.

Desmidium aptogonum var. **acutius** Nordstedt. Hart Co. **D. baileyi** (Ralfs) Nordstedt. Hart Co. **D. cylindricum** Greville. Hart Co. **D. swartzii** Agardh. Hart Co., Hickman Co.

Euastrum ansatum Ralfs. Larue Co. **E. denticulatum** (Kirchner) Gay. Hart Co. **E. dubium** var. **anglicanum** (Turner) W. & G. S. West. Hart Co. **E. elegans** (Brebisson) Kützing. Hart Co.

E. gemmatum Brebisson. Campbell Co. **E. glaziovii** Borgensen. Hart Co. **E. insulare** (Wittrock) Roy. Hart Co. **E. obesum** Josh. Campbell Co., Hart Co. **E. oblongum** var. **cephalophorum** West. Hart Co. **E. verrucosum** Ehrenberg. Hart Co., Larue Co.

Hyalotheca dissiliens (Smith) Brebisson. Hart Co., Rowan Co.

Micrasterias americana (Ehrenberg) Ralfs. Hart Co. **M. denticulata** Brebisson. Hart Co. **M. laticeps** Nordstedt. Hart Co. **M. radiata** Hassall. Hart Co. **M. truncata** (Corda) Brebisson. Fayette Co.

Onychonema laeve Nordstedt. Hart Co. var. **latum** W. & G. S. West. Hart Co.

Penium closterioides Ralfs. Fayette Co., Hart Co. **P. curtum,** forma **major** Wille. Fayette Co. **P. margaritaceum** (Ehrenberg) Brebisson. Barren Co., Fayette Co., Hart Co., Larue Co., Nelson Co. **P. minutum** (Ralfs) Cleve. Hart Co. **P. spirostriolatum** Barker. Hart Co.

Pleurotaenium coronatum var. **nodulosum** (Brebisson) West. Hart Co. **P. ehrenbergii** var. **undulatum** Schaarschmidt. Hart Co. **P. trabecula** (Ehrenberg) Nägeli. Campbell Co., Fayette Co., Hart Co., Scott Co.

Spondylosium secedens (De Bary) Archer. Hart Co.

Staurastrum alternans Brebisson. Fayette Co., Hart Co. **S. anatinum** var. **denticulatum** G. M. Smith. Fayette Co., Jessamine Co. **S. bieneanum** Rabenhorst. Fayette Co., Hart Co. **S. botrophilum** Wolle. Larue Co. **S. chaetoceras** (Schröder) G. M. Smith. Bourban Co., Fayette Co. **S. cuspidatum** Brebisson. Hart Co. **S. dickiei** var. **circulare** Turner. Hart Co. **S. gladiosum** Turner. Hart Co. **S. manfeldtii** Delponte. Fayette Co. **S. muticum** Brebisson. Fayette Co. **S. paradoxum** var. **parvum** West. Fayette Co. **S. polymorphum** Brebisson. Barren Co., Carroll Co., Clark Co., Fayette Co., Hart Co., Jessamine Co., Larue Co. **S. pseudotetracerum** (Nordstedt) W. & G. S. West. Fayette Co. **S. striolatum** (Nägeli) Archer. Barren Co., Fayette Co., Garrard Co., Hart Co., Jessamine Co. **S. tetracerum** (Kützing) Ralfs. Hart Co.

Xanthidium antilopaeum var. **minneapoliense** Wolle. Hart Co. var. **polymazum** Nordstedt. Hart Co. **X. cristatum** Brebisson. Hart Co.

EUGLENINEÆ.

Euglenaceæ.

Euglena spirogyra Ehrenberg. Campbell Co.

The following is a summary of all forms found, giving the numbers of species for each of the classes, sub-classes, orders, families, and genera:

MYXOPHYCEAE, 68.

CHROOCOCCEÆ	21
Chroococcales	21
Chroococcaceæ	21
Aphanocapsa	2
Aphanothece	1
Chroococcus	3
Coelosphaerium	3
Gloeocapsa	1
Gomphosphaeria	2
Merismopedia	5
Microcystis	4
HORMOGONEÆ	47
Hormogonеales	47
Oscillatoriaceæ	25
Lyngbya	5
Microcoleus	1
Oscillatoria	13
Phormidium	5
Spirulina	1
Nostocaceæ	19
Anabaena	7
Aphanizomemnon	1
Cylindrospermum	5
Nodularia	1
Nostoc	5
Scytonemataceæ	1
Scytonema	1
Rivulariaceæ	2
Calothrix	1
Gloeotrichia	1

CHRYSOPHYCEAE, 1.

Ochromonadales	1
Ochromonadaceæ	1
Dinobryon	1

RHODOPHYCEAE, 1.

FLORIDEÆ	1
Nemalionales	1
Lemanaeceæ	1
Lemanea	1

HETEROKONTEAE, 5.

Heterotrichales	4
Tribonemaceæ	4
Tribonema	4
Heterosiphonales	1
Botrydiaceæ	1
Botrydium	1

CHLOROPHYCEAE, 298.

ISOKONTÆ	130
Volvocales	8
Chlamydomonadaceæ	1
Chlamydomonas	1
Volvocaceæ	7
Eudorina	1
Gonium	1
Pandorina	1
Pleodorina	2
Volvox	2
Chlorococcales	95
Palmellaceæ	6
Gloeocystis	1
Planctosphaeria	1
Sphaerocystis	1
Tetraspora	3
Hydrodictyaceæ	14
Hydrodictyon	1
Pediastrum	13
Chlorococcaceæ	3
Characium	2
Chlorococcum	1
Dictyosphaeriaceæ	3
Dictyosphaerium	2
Dimorphococcus	1
Autosporaceæ	69
Actinastrum	2
Ankistrodesmus	3
Closteriopsis	1
Coelastrum	2
Crucigenia	6
Errerella	1
Gloeotaenium	1
Golenkinia	3
Kirchneriella	4
Lagerheimia	3
Micractinium	2
Nephrocytium	1
Oocystis	4
Quadrigula	1
Scenedesmus	20
Schroederia	1
Selenastrum	3
Sorastrum	1
Tetraedron	9
Trochiscia	1
Ulotrichales	12
Ulotrichaceæ	2
Ulothrix	2
Cylindrocapsaceæ	1
Cylindrocapsa	1
Pleurococcaceæ	1
Pleurococcus	1
Chaetophoraceæ	6
Chaetophora	1
Draparnaldia	2
Stigeoclonium	3
Coleochaetaceæ	1
Coleochaete	1
Trentepohliaceæ	1
Trentepohlia	1

SIPHONOCLADIALES	11
Cladophoraceæ	11
Cladophora	5
Pithophora	1
Rhizoclonium	5
SIPHONALES	4
Vaucheriaceæ	4
Vaucheria	4
STEPHANOKONTÆ	18
OEDOGONIALES	18
Oedogoniaceæ	18
Bulbochaete	1
Oedogonium	17
AKONTÆ	150
ZYGNEMALES	30
Zygnemaceæ	30
Debarya	1
Mougeotia	1
Spirogyra	26
Zygnema	2
DESMIDIALES	120
Mesotaeniaceæ	1
Netrium	1
Desmidiaceæ	119
Arthrodesmus	1
Closterium	27
Cosmarium	42
Desmidium	4
Euastrum	10
Hyalotheca	1
Micrasterias	5
Onychonema	2
Penium	5
Pleurotaenium	3
Spondylosium	1
Staurastrum	15
Xanthidium	3
EUGLENINEAE, 1.	
Euglenaceæ	1
Euglena	1

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Volume V by **Dr. Nellie Carter.**

A COMMUNITY OF CHARITY CASES.*

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Steele High School, Dayton, Ohio.

Since charity work in many cities has been organized as a community project, the character of the person helped becomes a question of concern to the average citizen. That families making repeated appeals for aid have some common characteristics might be expected. This study was begun as an attempt to find some of these common factors in an Ohio city with a population of 150,000. This City was among the first to adopt the "Community Chest" plan and the charity work is well organized. The cases selected were those of families who had applied many times for aid through the organized charities. The files of the Family Welfare Association furnish a history of the cases that have come to their attention since 1913. From these records over fifty cases were reviewed and twenty-nine of these cases form the basis of this study. In following up these histories with field observations seventy homes were visited and one hundred and fifty of the persons charted seen.

A problem which presented itself early in the field work was locating the families. Unless the appeal for aid had been very recent, the records of the Family Welfare Association could be of little use. Tracing the residence record of the family is not a problem of the Association as the family will sooner or later make an appeal from the new address. In a re-check of ten families after a six-months' period, six were found at new addresses and one family had moved twice. With so much shifting it was surprising to find that few members of the families studied had ever left the city after once establishing their residence. One reason for this continuous residence is found in the policy of organized charities to give substantial relief only to their own citizens. When this study was begun three of the families were stranded in Davenport, Iowa. They had started west and their automobiles had broken down at that place. The Associated Charities of Davenport decided that an investment in transportation would be more profitable

*Contribution No. 101 from the Department of Zoology and Entomology, Ohio State University.

than an uncertain expenditure for food and clothing, so the three families, eighteen persons in all, were helped back to the city. One of these families has applied for aid at the Family Welfare Association since its return.

Not only has their residence in the city been continuous, but most of the families, when finally located, were found within a very limited area of the city. Two areas, both in the poorer residential parts of the city, seemed especially favored. Although separated by the river, railroads, and factory district, these two areas belong to adjoining school districts. The only members of the group not in these areas were those who had moved out into adjacent plats where small houses could be had at low rent.

Housing conditions were of the poorest and none of the homes were in good repair. Many lived in antiquated tenement houses with three or four rooms to an apartment, small cottages, often on alleys, or rooms. These rooms were usually upstairs or in the rear. The rent ranged from ten to twenty dollars per month. Often two families occupied the same rooms. In only two cases did a family occupy a two-story house by themselves. In a few cases "rooms" were rented "furnished," some families owning only a little bedding and a few dishes. Despite the fact that most of the homes were meagerly furnished there was usually an effort at cleanliness and some homes were quite neat.

For the most part the men were the sole bread winners but occasionally the men were found at home while the women were out at work. Four such cases were found, or about six per cent of the homes visited. The employment of the men was limited to a few classes of work, mainly laborers, truck drivers, and helpers. None had any definite trade and few worked in shops, although a small group aspired to be contractors in painting. Because of the uncertainty of weather conditions, many were forced to be idle much of the time. Truck drivers with regular routes and helpers in filling stations were the most prosperous. If the class of labor done is a criterion, this group is below the level of the average in intelligence.

The women working outside the home were usually in restaurants and bakeries. One did sewing at home and one worked in a factory. Because the housekeeping efforts are so successful one is apt to over-estimate the mentality of the

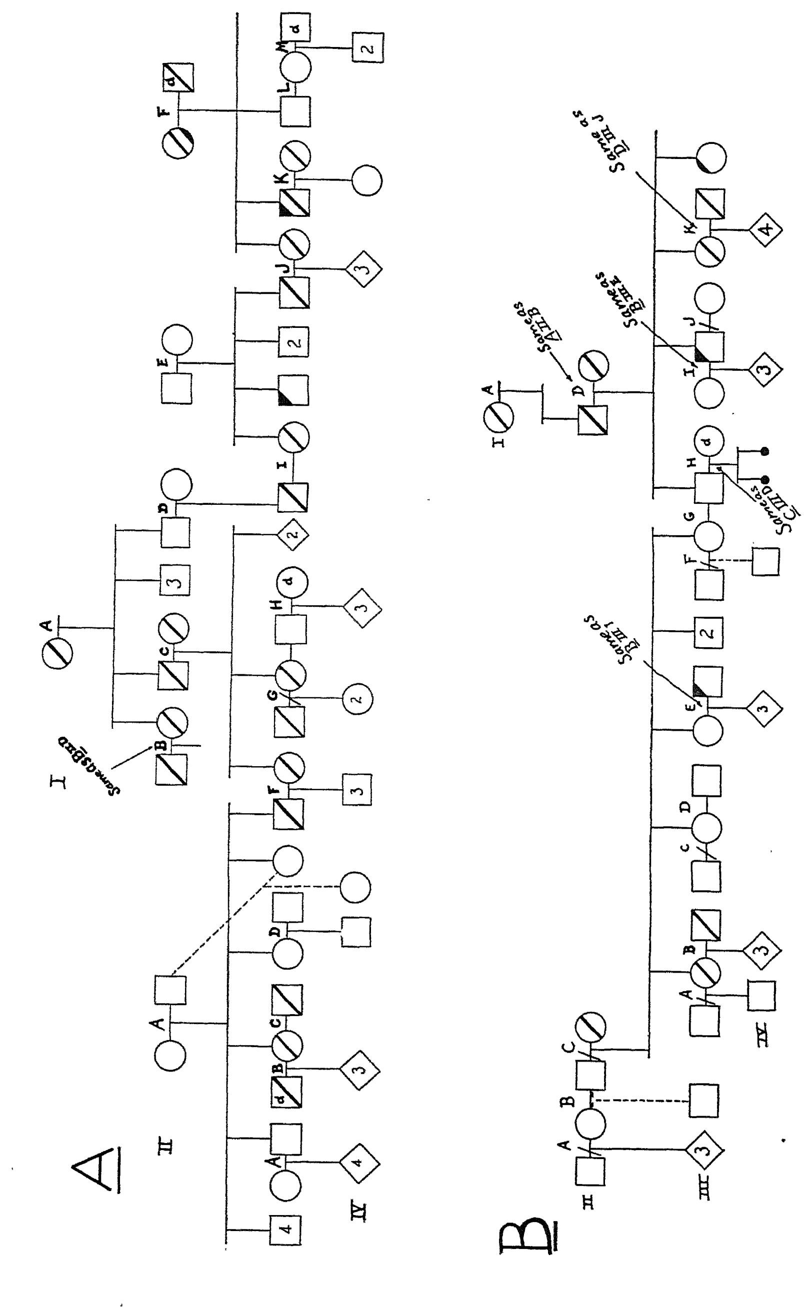
home keeper. A little questioning regarding persons and events, and more especially questions concerning directions and locations, reveals the intelligence of the women on a par with that of the men.

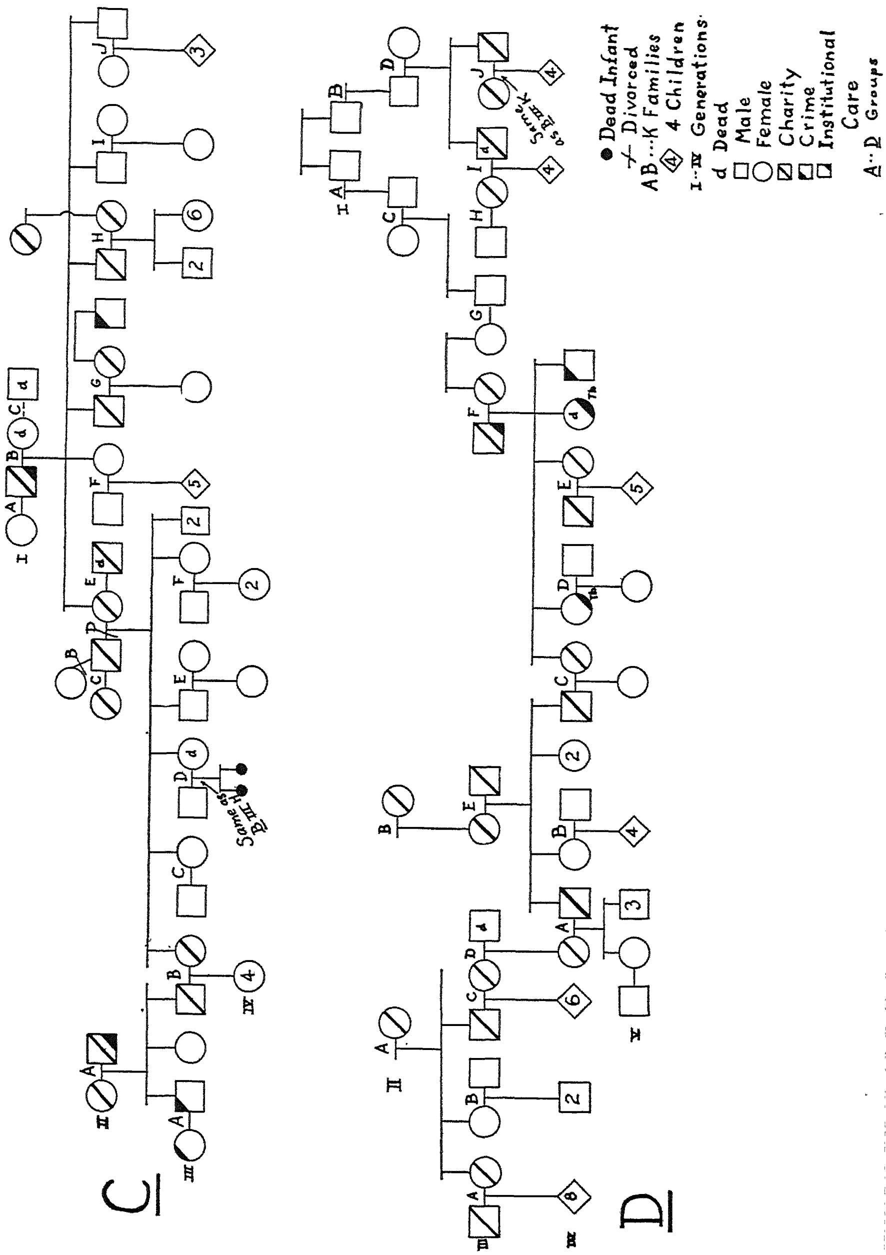
The school attainment of the children is limited to the sixth and seventh grade. Four of the children have been in "special classes" and most of the others are below the school grade usual for their age. Of the twenty-nine children above the first grade there was a total retardation of forty-three years. This is a year's work for one teacher. This group of twenty-nine was receiving one-third more attention than the average school group of its size.

Taking the cases from court records, certain types of crime are found to be common. Three have been convicted of theft, one of boot-legging and two of peddling dope. Sex offences are frequent in some families. There are three illegitimate children in the group, one being a case of incest. The record of one family is striking in that nearly all have been divorced and re-married. Separations and desertions are frequent occurrences. Early marriage is common within the group. There are few single men or women over twenty years of age. One fifty year old woman had a married granddaughter.

Several of the families selected were found to be related through marriage. Two large related groups of families each connected with a third large family which, though usually thrifty enough to tide itself over times of stress, was still close to the borderline of dependence. Using this family as a connecting factor all the group resolved itself into an inter-related community. The situation is strikingly similar to that of an isolated rural community of the last century. The social barriers separating the group from its neighbors are as effective as distance was to the frontiersman. The other cases reviewed from the Family Welfare Association records show the same tendencies to remain within a limited area and intermarry within their own group. The accompanying chart shows the relationships among the families visited.

Some of the families were most striking in their dependence on charity. N. C—— whose father is in the County Infirmary has received aid while she was living with each of her two husbands. Two of her brothers have received aid and her youngest son received extra attention in a "special" class in




C
D
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AB...K Families
4 Children
I..IV Generations
d Dead
Male
Female
Charity
Crime
Institutional Care
A..D Groups

school. Her oldest daughter will probably need assistance for some time, as she is separated from her husband, and is trying to care for her four children. The father's assistances to the support of these children is gotten by the Humane Society, and they must re locate him frequently because of his attacks of wanderlust. W——'s mother has gotten help at various times so has W—— and two of his daughters, also a nephew and the nephew's brother-in-law. In the family of D—— three generations have received help, so also has the L—— family.

The rehabilitation of one of these families is always temporary. Only under the most favorable conditions can they remain self-supporting. Both parents and children come for help whenever the conditions become adverse. Institutional care is the future of those who outlive their earning period, for the family is never able to carry the burden of an additional unproductive member. When the study was made five of the group were being kept in some tax supported institution and one other living member had been in the State Hospital on two occasions.

If the children of those families which have received aid through the Welfare Association are considered by themselves, the incidence of dependence is striking. When the parents of one or both parties have received help the chances are about two to one that the family will apply for aid by the time a second child is born. And it will be remembered that the Welfare records cover a period of only sixteen years.

Although the selection of cases implied a long residence in the city there was found to be a wide range in the length of residence. One gray-haired woman, with her husband in an institution for epileptics, a daughter in a T. B. sanitarium, and a son at large, had spent her entire life within a dozen blocks of where she was born. Others have been in the city only a few years. The greatest influx of these families seems to have been from 1910 to 1915. The movement into the city aside from a few coming in from nearby farms and villages was very largely from the south. The hill country of Kentucky and Tennessee furnished more than 60% of the families. A study of the surnames is significant. English, Irish and Scotch names predominate. It would be interesting to trace these family names back to the early Colonial settlers and to England.

The vigorous robust individual is a rare exception in this group. One boy is interested in baseball and plays on a neighborhood sand lot team. He is the only one inclined toward athletics. Most of the men are below the average in size and apparently underweight. Their power of disease resistance is much below the average. One very common form of charity accepted by them is the free clinic and hospital service. This impression may have been gained by their willingness to talk of their hospital experiences.

The question of drunkenness is ignored. It is assumed that drunkenness is an effect of some more remote cause. Attitudes on the liquor question are as one finds them in any group. Many spoke of drinking among others in the group but usually about those for whom they had a dislike. Just how much drinking was excused among friends one could only surmise.

Generalizing on so few cases can hardly be done with satisfaction but some conditions are so common as to be outstanding. A most striking characteristic was the unquestioning willingness of the subject to give information. This, in my opinion, is associated with the child-like simplicity of the feeble-minded. The willingness to answer questions was all the more noticeable as the investigator went as an individual, not backed by an organization. Had the subject thought that a charity organization was interested excuses to apply for aid would have been forth-coming.

Another characteristic noticed was the cheerful, hopeful outlook on life. Very few were despondent. There is a record of one suicide but this seems to have been started by a bluff and the disasterous turn in the situation was unexpected. Their attitude toward help from the outside seemed to be a passive one. There was little insistance on charity as an inherent right.

These families are living in a poor neighborhood under poor housing conditions with poor food and clothing. Their immediate environment offers little and they can not take advantage of the opportunities for advancement offered them through the schools and other educational agencies. Their ancestors in the hill country failed to meet successfully the simple demands of a rural life and the children are experiencing more difficulties in meeting the complex life of the city. In trying to determine a

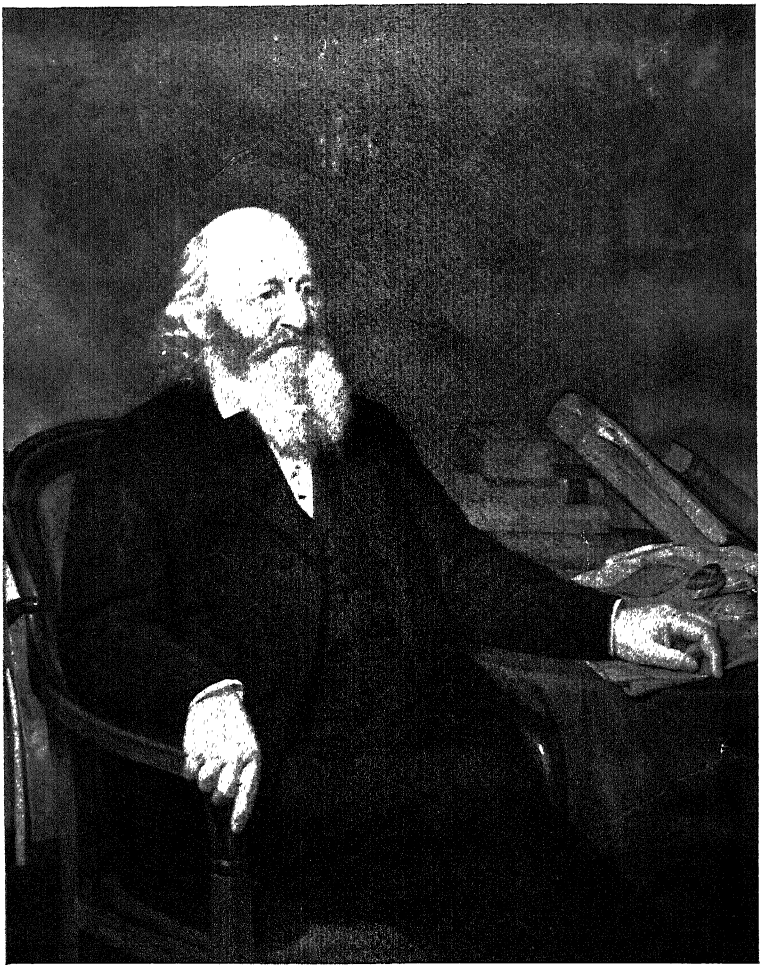
single causal factor contributing to their delinquency one has a problem as complex as that of Father Jupiter in "The Bridge of San Luis Rey." In general, one can say that the inherited factors which keep them dependent lie within the comprehensive grouping of mental status known as feeble-mindedness.

ANNUAL MEETING

OF THE

OHIO ACADEMY OF SCIENCE.

Notices of the Spring meeting of the Ohio Academy of Science have been sent to all members but for the benefit of any not now connected with the Academy it may be noted that the meetings will be held at the Ohio State University, Botany and Zoology Building, April 18 and 19. Those interested in Science are welcome to these meetings and to membership in the Academy. Applications for membership may be sent to the Secretary, Mr. W. H. Alexander, Weather Bureau, Columbus, Ohio.



(From an oil painting done by Allen Smith in 1870.)

JARED POTTER KIRTLAND
1793—1877

To face page 153

THE OHIO JOURNAL OF SCIENCE

VOL. XXX MAY, 1930 No. 3

JARED POTTER KIRTLAND,

PHYSICIAN, TEACHER, HORTICULTURIST, AND EMINENT NATURALIST.*

FREDERICK C. WAITE,
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The adolescent in science like the adolescent in youth is more likely to be impressed by good example than by much exhortation. The choice of my subject is in part influenced by the desire to bring to the attention of the younger members of the Ohio Academy of Science a scientist whom they may well emulate.

To the more mature as well as to the younger, it is both of interest and advantageous to be reminded of those who have preceded us and to learn something of their careers. It is especially fitting that the Ohio Academy of Science should acknowledge its indebtedness to the pioneers of science in Ohio.

Therefore I have chosen as my topic to sketch the life and career of Jared Potter Kirtland, who so largely influenced the development of interest in natural science in Ohio.

ANCESTRY.

We have long heard much discussion as to the relative importance of inheritance and environment, not only in biological doctrine, but as well in human society. However, when an individual is the happy recipient of both favorable ancestry and of advantageous surroundings and opportunity there is a summation of the influence of inheritance and environment that promises important results.

*Presidential Address before the Ohio Academy of Science, April 18, 1930.

Nathaniel Kyrtland (1616-1686) came from Tickford, Buckinghamshire, England to Massachusetts Bay in 1635 and settled at Lynn. His son, Lieutenant John Kirtland (1659-1716), migrated to the lower Connecticut Valley and settled at Saybrook, Conn. Here he and his children played important parts in colonial history. He himself became commander of the fort at Saybrook Point and led his fellow colonists in several battles with the Indians in the closing years of the seventeenth century. One of his descendants, John Thornton Kirkland, (1770-1840),—for the two names are but variants—was President of Harvard College from 1810-1828. Rev. Samuel Kirkland, the renowned missionary to the Indians, was also a descendant. Early in the eighteenth century several of the family moved up the river to Wallingford, Connecticut. Here in 1755 was born Turhand Kirtland, the father of the subject of this sketch.

When in 1796 the Connecticut Land Company bought three million acres in that area of north-eastern Ohio known as the Connecticut Western Reserve, its officers sought a man to represent them as resident general agent in this frontier area. Their choice in 1797 fell upon Turhand Kirtland, a veteran of the Revolutionary War then forty-two years of age, and it proved a wise choice, for during the closing years of the eighteenth century and the early decades of the nineteenth century this man showed himself brave, resourceful, and just. He had both breadth of vision and integrity and to him largely is due the fact of unbroken friendliness between settlers and Indians in that region. He was an associate judge, a member of the state senate and a trustee of Western Reserve College.

In testimony of his attitude toward the Indians one incident will suffice. Soon after Turhand Kirtland came to the Western Reserve in 1797, a white man killed an Indian in a drunken brawl. Kirtland at once had the white man arrested. There were no established courts in that part of the state but he sent to Marietta and induced two duly appointed judges to journey two hundred miles to try the white man. Primarily on the testimony of Indians who were eye witnesses of the killing, self defense was proven and the man acquitted. The Indians were entirely satisfied. This incident so firmly established the reputation of Turhand Kirtland for fair dealing that he became the accepted arbitrator when the Indians had any disagreement with the white settlers.

Not only on the paternal side, but also on the maternal side, Jared Potter Kirtland was fortunate in his ancestry. His mother, Mary Potter, counted in her forbears, both direct and collateral, a line of able and influential persons. Her father Dr. Jared Potter (1742-1810) was reputed to be the leading and most learned physician in the Connecticut of his day. Graduated at Yale in 1760, he studied medicine with the most scholarly physician in that colony and early acquired an interest not only in medicine but in many other lines of knowledge including natural history. He continued throughout his life to be a student and a leader in his profession founding the first State Medical Society of Connecticut. He was also a leader in his community and was continuously a member of the legislature for the last eighteen years of his life.

EARLY LIFE AND EDUCATION.

Jared Potter Kirtland, the eldest son of Turhand Kirtland and Mary Potter his wife, was born at Wallingford, Connecticut, November 10, 1793. He was ten years of age when his father moved the family to Ohio, but the lad was not taken to the frontier. Instead he was put into the home of his grandfather, Dr. Jared Potter, under whose guidance for seven years he was carefully educated, and in his boyhood days, learned to like to study. As a boy he took prizes in Mathematics, in Greek, and in Latin. He acquired that taste for the classics that resulted in his reading the classic authors in the original as a recreation up until the closing years of his life.

It was not alone in formal school study that he was trained. His grandfather inculcated in the boy a love of natural history and taught him accurate observation and the habit of recording his observations, a habit which was maintained throughout his life and in large measure accounts for the wealth of original observations shown in all his writing. Dr. Potter had an extensive orchard which included mulberry trees where the attempt was being made to produce silk. At ten years of age the lad was carrying on experiments in improving fruit trees by budding and grafting. At eleven he was making experiments with bees and studying their enemies. At twelve he made his first scientific discovery of importance when he showed, by breeding experiments, that the silk worm moth can reproduce parthenogenetically, something that had never

before been recorded, and preceding by nearly fifty years Siebold's work on parthenogenesis.

At fifteen years of age in 1808 he made a summer trip to Ohio. At seventeen years of age Jared Potter Kirtland came to Ohio to his father's residence at Poland, Ohio. Here he taught school, but his chief interest was in exploring the adjacent country, observing the flora and fauna, and working in his father's orchards.

PROFESSIONAL EDUCATION.

Before a year had elapsed Dr. Jared Potter died (July 1810), making a considerable bequest to his grandson and giving him his rather extensive library. Thereupon young Kirtland returned to Wallingford, Conn. and began the study of medicine under the preceptorship of two local physicians. During a part of this time he was studying at Yale College as a private pupil of Professor Eli Ives in botany and of the elder Silliman in mineralogy and geology, both of these men having been friends of his grandfather. The fortunate circumstances that brought Kirtland in his youth into intimate contact, first with Jared Potter, and later with Ives and Silliman had great influence upon his scientific career for all three were men of outstanding ability and scientific zeal.

With the bequest of his grandfather, Kirtland, yet under twenty years of age was able to plan his career without financial restriction. His purpose was to go to the University of Edinburgh to study medicine, but before he was ready to depart the war of 1812 came on and that procedure had to be abandoned.

It happened that just at that time Dr. Nathan Smith, eminent as a medical teacher, came from Dartmouth to found the Yale Medical Institution and in 1812 at the age of nineteen Kirtland became the first matriculant in that new medical school. After one session, he did the common thing of migrating to another school and went to the University of Pennsylvania where he spent the session of 1813-14. Here he came into close relations to Barton the botanist under whom he wrote a thesis.

In 1814 Kirtland was in bad health and he spent some months in Wallingford and in the autumn of 1814 returned to the Yale Medical Institution where he graduated in medicine in March 1815 at the age of twenty-one.

His education had brought him into contact with the leading medical school of the country and with two of the best colleges, but also it had given him rather intimate relations with three of the leading scientists of the day namely Barton, Ives, and the elder Silliman and with Dr. Nathan Smith, leading medical teacher. This, in addition to his early training under his grandfather Dr. Jared Potter and his own taste for study, gave him a background rarely accorded in that day. His environment and opportunities had been most favorable toward developing his innate ability, a heritage from an able ancestry.

MEDICAL CAREER.

On graduating in medicine Dr. Kirtland married and returned to Wallingford, Conn., his native town, to practice medicine. His popularity is attested by the fact that within about a year, at the age of twenty-three, he was elected judge of probate. He practiced medicine at this location for five years and then moved to Durham, Conn. Here in 1823 his wife and second child died. The result was a great despondency.

He now, at the age of thirty, resolved to abandon medical practice and moved to Poland, Ohio, planning to follow his father, then seventy years of age, in the conduct of the extensive mercantile business he had there developed. But a pioneer community with no other well-trained physician in it would not permit Dr. Kirtland to remain inactive medically. He soon was deep in an extensive medical practice, and had abandoned his idea of store-keeping, but not of avocations. In 1825 he again married. His country riding gave him opportunity to study the flora and fauna, and soon he focused attention on the fresh water bivalve mollusca of the Mahoning river, which led to two important contributions to zoological knowledge. He discovered in 1829 that the individuals of these mollusca are of separate sexes, instead of hermaphroditic as always had been taught before that time. This discovery was first published in 1834 in the American Journal of Science. In the same journal in 1840 he published the discovery of the byssus, the larval organ of attachment in these animals.

These two discoveries made his name known in Europe and brought him the friendship of prominent American zoologists, not least of whom was Louis Agassiz.

Natural history was not his only avocation. He continued the interest of his boyhood in improving fruits and developed on his farm at Poland, Ohio, excellent orchards and small fruits, and as early as 1831 began writing for horticultural journals.

He became well known and popular in his community and in 1827 was elected to the legislature and twice reelected. In the legislature he was at once put on several important committees and on his first reelection he was made chairman of the Committee on the Penitentiary. In that session he carried through a reform in the management of the Ohio penitentiary whereby useful labor replaced solitary confinement, a change so well accepted that he was called the "Father of the Penitentiary." He also had important influence in the legislature toward the construction of the Ohio and Pennsylvania canal.

With all these activities his medical practice extended and, in the middle 1830's he came to have the reputation of being the best and most learned physician in northern Ohio. He was active in the State Medical Convention, being its president at its third session held in Cleveland in 1839, where, as his presidential address, he presented an extensive review of the climate and meteorology of Ohio since its first settlement and the relation of these conditions to the diseases of that period. Later, in 1849 he was made president of the State Medical Association.

CONNECTION WITH OHIO GEOLOGICAL SURVEY.

Beginning in South Carolina in 1823 there was a wave of organization of state geological surveys. By 1836 it included ten of the eastern and southern states and also a United States Survey. In 1836-37 the first Ohio Geological Survey was organized. In this survey Dr. Kirtland was put in charge of Zoology. In the membership of the survey there were three other physicians, namely, Drs. S. P. Hildreth, John Locke, and John L. Riddell. Dr. Kirtland worked with great energy. Financial support from the legislature was scanty but Dr. Kirtland not only suspended his own pay in order that the geological features of the survey might proceed but also he personally paid the stipends of his assistants so that the work in zoology might go on. Only when the project was entirely abandoned did he desist. Out of this work came his list of

Ohio Vertebrates containing 585 entries and his pioneer work on the Fishes of Ohio, which, the state refusing to print, was published in the Journal of the Boston Society of Natural History in 1839-1846. In 1840 he published a description of the kidney worm parasitic in swine, the first record of its occurence in America.

TEACHING CAREER.

In 1837 there was a vacancy in the Professorship of the Theory and Practice of Medicine on the faculty of the Medical College of Ohio at Cincinnati, then the only regular medical school west of the Alleghenies and north of the Ohio river. To this vacancy Dr. Kirtland, a country practitioner, was called. Here at forty-four years of age he began his career in medical teaching which continued for nearly thirty years, a career marked by the reputation of breadth, clarity, scholarliness, and practicability, and withal outstanding in excellence.

In 1837, the same year that he began teaching medicine in Cincinnati, Dr. Kirtland left Poland, Ohio and bought a farm at Rockport, five miles west of the center of Cleveland, where he resided for forty years until his death in 1877. Here he continued extensive experimentation in various branches of horticulture. He spent the teaching term from November to March at Cincinnati and the balance of the year at Rockport. This continued for three years. Then he resigned at Cincinnati and in 1840 joined the faculty of the Willoughby Medical School. This change permitted him to live the year round on his Rockport farm where his experimental work was broadening.

In 1838 he had as a colleague on the medical faculty in Cincinnati, Dr. John Delamater, a man at that time reputed to be the best medical teacher in the United States, and who in his teaching career held professorships in nine different medical schools. Dr. John Delamater was the leading figure in the Willoughby Medical School and it was through his influence that Dr. Kirtland joined that faculty in 1840. There he first met Dr. John Lang Cassels, a Scotchman educated in the University of Glasgow and at a New York medical school, who later did important work in Botany and Geology.

In 1843 Dr. Kirtland with Delamater, Cassels, and Dr. Horace A. Ackley resigned from the Willoughby Medical School and founded the Cleveland Medical School (now the

School of Medicine of Western Reserve University) in which Dr. Kirtland continued as Professor of Medicine until he reached the age of seventy-one, in 1864.

CONNECTION WITH SCIENTIFIC SOCIETIES.

On that faculty was a group of seven scholarly men said to constitute one of the best balanced medical faculties in the country, and also there were other able men in the community who were interested in natural science. These Dr. Kirtland, in 1845, organized into the Cleveland Academy of Natural Sciences. Of it Dr. Kirtland was president for twenty-five years until he was compelled to withdraw by reason of the feebleness of age. In his honor its name was later changed to the Kirtland Society of Natural History.

At its monthly meetings were presented able papers, not only by members but by visiting scientists. The range of subjects was wide and included many fields of Zoology, Botany, Geology, Paleontology, Mineralogy, and Meteorology. The Academy at once started a museum to which was contributed much valuable material. The present Cleveland Museum of Natural History is its direct lineal successor.

Dr. Kirtland had been active in a scientific society at Cincinnati during the three years of teaching there. In 1839 he became a member of the Boston Society of Natural History. He was one of the founders of the American Society of Geology and Natural History in 1840 and also of its successor, the American Association for the Advancement of Science, in 1845. He was a member of the Philadelphia Academy of Natural Science, and of the American Society of Conchology and probably of the natural history societies in New York and Chicago. In 1864 he became a member of the American Academy of Science, being elected to fill the vacancy caused by the death of Benjamin Silliman, the younger. In 1875 at eighty-two years of age he was elected a member of the American Philosophical Society. To all of these societies he contributed papers.

In addition to these societies of Natural Science, he held membership in a group of societies connected with agriculture and horticulture. In many of them he held offices, of several he became president and to all of them he contributed papers.

PUBLIC SERVICE.

Dr. Kirtland was always helpful in public service. Mention has been made of his service as probate judge and his career in the legislature. When the civil war came on he was sixty-eight years old. The government would not send him into the field but he served through the war as examining surgeon at Cleveland and turned over all his pay to be used in aiding soldier's families.

When Cleveland came to seek to supplant its wells and springs with lake water Dr. Kirtland was the most active one of a committee of three that planned and put into operation the first water supply system of Cleveland. Before the civil war he and two others (Drs. Nathan Strange Townshend and John Strong Newberry) established winter courses in agriculture given first at Oberlin and later at Cleveland. He was one of the small committee of the Ohio Agricultural Society that for many years sought the establishment of an agricultural college, a plan finally successful when, in 1874, instruction began in what has now become Ohio State University.

HIS GENERAL REPUTATION.

One would expect with such diversity and versatility there would have been superficiality but no evidence of it appears. On the contrary he appears to have excelled in every vocation or avocation to which he put his hand.

First of all there is plenty of evidence that he was held in high regard by profession and laity, through more than fifty years, as a very good general practitioner of medicine. He was considered both by colleagues and students as an excellent medical teacher. He held professorships of medicine in three different medical schools in Ohio covering a period of twenty-seven years of active teaching.

In horticulture he had an international reputation. This was not only as regards fruits, but extended to ornamental trees and also to floriculture. He did some work in animal breeding. He was elected to honorary membership in the most exclusive horticultural societies. He developed many new varieties of flowers and fruits. His results in the cultivation of cherries included the development of over forty new varieties and his success was so preeminent that he was referred to as the "Cherry King." Also he improved the culture of apples, pears,

grapes, raspberries, and strawberries. In other fields of agriculture he was considered an authority and was frequently quoted, in other parts of the country, on such diverse subjects as bee culture, windmills, and rural architecture.

HIS SCIENTIFIC CONTRIBUTIONS.

Dr. Kirtland was a prolific writer upon a great variety of subjects. In an attempt to compile his bibliography I have so far collected over two hundred titles of signed papers, beside many more, found in journals to which he was accustomed to contribute, that bear imprint of his style of writing but are not signed. Many of these are initialed "K" but may have been written by his brother Dr. Billius Kirtland, who was also a capable naturalist and horticulturist. Dr. Jared Kirtland's papers fall into four groups: medical, zoological, horticultural, and miscellaneous.

The medical papers are not numerous. I have but ten but these bear evidence of careful observation, clear deduction, and progressive thinking as to etiology, diagnosis, and therapeutics. It is of interest to note that in 1851 he wrote a paper in which he said he was convinced that typhoid fever comes from the drinking water. This was thirty years before we knew of bacteria.

Of the zoological papers I have been unable to locate his original description of parthenogenesis in the silk worm moth. In later papers he makes reference as to the facts and date of his experiments and discovery but does not say when it was published nor does he definitely say it was published. The first important papers were on the bisexuality of fresh water bivalve molluscs and the description of the byssus. These were published in the American Journal of Science in 1834 and 1840. The list of 585 Ohio vertebrates was published in the second report of the Ohio Geological Survey in 1838 and the series of papers on the Fishes of Ohio were published in the Journal of the Boston Society of Natural History from 1839-1846. Some seventy other zoological papers relating to parasitic worms, mollusca, lepidoptera, hymenoptera, fishes, reptiles, birds, and mammals appear in a variety of journals and society proceedings.

His zoological interests appear to have been centered on fishes and birds. He was not satisfied with merely possessing preserved specimens, but was interested in their food, their

habitat, habits, and range and especially in the occurence of previously unrecorded species. It will be recalled that a warbler was named after him. It is probably less well known that a bivalve mollusc, a snake and a fossil were also given his name by their discoverers.

INFLUENCE IN POPULARIZING NATURAL SCIENCE.

Great as was his influence upon professional men and those engaged in scientific pursuits, yet perhaps greater was his influence along scientific lines upon the laity. To appreciate this it is necessary to recall that before the Civil War this region was predominantly one of agriculture and that in rural communities reading was a much more popular art than it is today.

In 1850 Dr. Kirtland became editor of the Family Visitor, a popular weekly journal published first at Cleveland and later at Hudson, Ohio. This was less a publication of news events than a compilation of extracts from many sources. These extracts concerned social, literary, religious, and political affairs but there was a large number of articles on natural science including chemistry, physics, astronomy, meteorology, geology, zoology, and botany. Many of these were original articles. Some of these were by J. Lang Cassels and by Samuel St. John and many others were signed by Dr. Kirtland. Here he republished his work on the Fishes of Ohio and extended it. In his three years editorial connection with this periodical he clearly aimed to popularize natural science, and soon his readers began to send in inquiries and observations on fauna and flora and meteorology.

Dr. Kirtland occasionally contributed articles to the Ohio Cultivator founded in 1845. Its editor was Dr. Jehu Brainard another physician naturalist, an adherent of homeopathy, whose interest was more toward geology.

In 1851 was founded at Cleveland the Ohio Farmer. To this Dr. Kirtland became a leading contributor. His articles were given the most prominent position and usually accompanying editorial comment. After reading more than fifty of them I reach the conclusion that he wrote accurately and with a style that gives immediate interest. He tells of his own experiments, he quotes the experiments of others, and writes critically, constantly citing his own observations. All this is in excellent English with a style entirely lacking pedantry.

The Ohio Farmer had a wide circulation from the start and thus Dr. Kirtland had a large audience in those days, until his name was known at nearly every farmer's fireside in northern Ohio. Thus Dr. Kirtland was able to exert a wide influence in natural science. His subjects are varied and range from the description of some new animal form to the physics of windmill pumping. Horticultural subjects were numerous but also floriculture received much attention. Much over a hundred papers on horticultural and floricultural topics show a wide variety. They include papers on small fruits, insect pests, soil condition, manures, ornamental trees, apiculture, and many other things of interest to the farmer.

In a group of about twenty-five miscellaneous papers he discusses such subjects as garden and farm implements, the influence of amusements upon the elevation of taste, Sabbath observation, the peculairities of climate and its effects, methods and value of meteorological observations, public hygiene, animal instinct, the application of science to farming, landscape gardening, and rural architecture. In a paper on the latter subject in 1855 he advocated the use of cement as a building material for houses and barns, citing its advantages over both lumber and stone.

Dr. Kirtland was no mere theoretical writer, but his practice was as successful as his writing. At the county fairs and horticultural exhibitions his name appears again and again among the prize winners except in those instances where he was a member of the board of judges, which often happened, thus indicating that he had the confidence of the public.

Comparable to Dr. Kirtland's efforts and success in popularizing natural science with the laity was the stimulus he gave to interest in natural science through his influence upon his colleagues and his students.

He was the acknowledged leader of that group of professional men who became lovers of natural history and who made up the membership of the Cleveland Academy of Natural Sciences, among whom were such men as Brainard, Cassels, Garlick, Kirkpatrick, St. John, Winslow, and Whittlesy all of whom acknowledged the stimulus that Dr. Kirtland gave them. Dr. Kirtland was a frequent associate of Dr. Townshend to whom chiefly Ohio State University owes its origin. Dr. Townshend, also a physician and an ardent horticulturist, lived only a few miles away from Dr. Kirtland's residence.

Many of the students in the three medical schools where Dr. Kirtland taught caught from him the love of Natural History. All told he taught over three thousand medical students. He early established a museum in Cleveland Medical College and here he met the students to instruct them not only in medicine but in natural history. He lectured to them on birds, and bees, and insects. These men went far and wide to practice medicine and carried some liking for natural science and knowledge of it that they owed to Dr. Kirtland. No measure can be made of the influence of these men in natural science in the localities where they practiced but there is evidence that it was considerable. Some of these students became prominent in science. Of such Dr. John Strong Newberry, eminent geologist, is an example.

PERSONALITY.

One cannot discuss Dr. Kirtland without some reference to his personality. He was of a commanding physique and with a head that indicated intellectuality and carried dignity. He had a kindly countenance that inspired confidence. He was not only the loved physician but also the idol of the community in which he lived. He was familiarly known as the "Sage of Rockport," a testimony to the respect for his knowledge, but also he had an attractive personality that drew all to him.

One incident will illustrate this. In his study of birds he could find no one to do the taxidermy and so he trained himself in this art and then trained others to follow it. His own preparations were excellent enough so that some of them were accepted in leading European museums. Some of his pupils became professionally connected with various museums, but the incident that shows his personal charm is that when he was past seventy years of age a group of society young ladies of Cleveland weekly drove five miles to his residence to take lessons from him in preparing skins and mounting birds. This seems to bear testimony of personal charm when a man of seventy attracted society maidens to indulge in the somewhat messy work of taxidermy.

His simplicity and lack of egotism was proverbial. One anecdote will suffice to show this as well as his sense of humor. On an occasion a prominent eastern horticulturist who had not met Dr. Kirtland came to Cleveland to consult him. Driving

out to Dr. Kirtland's home he stopped his horse and seeing an old gentleman in torn straw hat and overalls hoeing among the flower beds he accosted him with the question "Is this the home of Professor Kirtland." The reply was "It is." "Is Professor Kirtland at home?" The man with the hoe replied, "He is." Then the visitor said, "Well my man come and hold my horse." Obediently the old gentleman advanced and held the stranger's horse while the visitor, preening himself, advanced to the door of the residence which was opened by Dr. Kirtland's daughter. He asked "Where can I find the renowned Professor Kirtland?" The daughter replied "He's out there in the street holding some man's horse."

Dr. Kirtland although not wealthy happily had sufficient resources so that he was able to be benevolent. This extended to both public and private contributions. The incidents in reference to the pay of the assistants on the geological survey and the contributions to soldier's families have been mentioned. Another more extensive is equally pertinent. When in 1845 the erection of a building for the Cleveland Medical College was halted for lack of funds, Dr. Kirtland, though but one of seven organizers of the school, on his personal note borrowed $3000 to complete the $8000 building, a note that was not paid until nearly twenty years later. His private benevolences were also numerous but unheralded.

LATER YEARS OF LIFE.

In 1864 at the age of seventy-one Dr. Kirtland resigned from his teaching duties, and also largely retired from medical practice, to devote himself to natural history and horticulture. A few years later he made a natural history trip of several weeks to Florida, and even at eighty years of age was active but soon his physical vigor began to abate and for the last few months of his life he was physically feeble but still alert mentally and intellectually, approaching the end with dignified confidence. He died quietly and peacefully at Rockport, Ohio, December 10, 1877, having by one month passed his eighty-fourth birthday. The community as a whole watched the closing days of his life and mourned his going but rejoiced in his career, and throughout the country in many a scientific group formal acknowledgment was made of his greatness.

CONCLUSION.

At a distance of a half a century we recognize here a truly great career. Here was a man who was physician, teacher, judge, legislator, editor, writer, horticulturist, and a real scientist. For us who falteringly follow in the footsteps of such great men it is of value to attempt to make an analysis and separate out some of the elements which made this career so outstanding.

First of all was the heritage of the idea of the nobility of accomplishment and service coupled with unselfishness. This came from a line of pioneers, who, by reason of small numbers, were forced to cooperate and could not succeed if they were selfish. The man who makes science his vocation rarely succeeds if his chief aim is personal aggrandizment.

Next was the forcefulness of early education. It seems that if any one individual deserves especial credit for Dr. Kirtland's career that person is his grandfather Dr. Jared Potter who taught this lad to study, to work hard, to record his observations and encouraged him in experimentation and independent thinking.

A third factor was the opportunity for intimate contact with a few great scientists of his day. These he admired and emulated and these contacts guided the capabilities started in the training of boyhood. Today the opportunity for contact with trained scientific minds is so common-place as to be little appreciated and often neglected.

Next comes the fact of Dr. Kirtland's catholicity of interest. He was no narrow specialist shut up in the confines of the study of a single phenomenon or of a single group of biological forms. His breadth of information, originally secured, gave opportunity for comparison which developed judgment, wisdom, and sagacity.

Then comes the habit of orderliness begun in early youth in making records and continued as evidenced by his writing. If one reads any of Dr. Kirtland's papers he is immediately impressed with the logic of presentation. The major premises have their proper position. The elaboration is clearly that and not a part of the premise and in brief and cogent phrases he proceeds to a conclusion which the reader is forced to accept. His style is terse and correspondingly convincing. In science neither the

disorderly mind, nor the disorderly laboratory leads to successful fruition.

Finally the outstanding element in this career is industry, orderly industry, the capability of working constantly and assiduously toward definite goals. At his death his most intimate scientific friend, Dr. Theodatus Garlick, an associate of forty years said of him "His eminent success in the field of science is attributable to his untiring industry and his inextinguishable thirst for knowledge."

ENVOY.

The Ohio Academy of Science has a noble heritage in the careers of Ohio's pioneer naturalists. The lives of Hildreth, Kirtland, and Sullivant, to mention but three, beckon us to fruitful tasks. Today's opportunities for progress are great, far greater, than these pioneers could imagine in their fondest hopes. It remains for us, and those that follow us, to develop those three qualities which characterized the personal career of Jared Potter Kirtland, namely catholicity of interest, orderliness, and personal industry.

A REVISED LIST OF THE FISHES OF OHIO.*

RAYMOND C. OSBURN, EDWARD L. WICKLIFF
AND MILTON B. TRAUTMAN.

Nearly thirty years have elapsed since a list of Ohio fishes was issued. (The Fishes of Ohio, Osburn, Special Paper No. 4, Ohio Academy of Science, June 1901). In this report 134 native and 3 introduced species were listed from actual records of fishes taken within the limits of the state.

For a number of years after this time very little work was done on the fishes, but in 1920 systematic collecting was again undertaken by the senior author, assisted by Mr. Wickliff and others in a survey of lakes and streams for the State Division of Fish and Game. Since that time some collecting has been done every summer in connection with biological studies of the waters of the state. This work, initiated and supervised by Osburn, has been carried on chiefly by Wickliff and Trautman, though a number of others have contributed to a lesser extent. The State Division of Fish and Game (now the Division of Conservation) has financed the work, with the exception of that carried on in Lake Erie every summer by the Franz Theodore Stone Biological Laboratory of the Ohio State University.

The list now numbers, as presented here, 144 native and 4 introduced species and 9 of these are represented within the limits of the state by additional subspecies, making a total list of 157 more or less distinct kinds of fishes in Ohio. Several names have been dropped from Osburn's list for the following reasons: *Ameiurus vulgaris* Thompson is an occasional long-jawed variant of *A. melas* and *A. nebulosus; Carpiodes thompsoni* Agassiz is synonymous with *C. velifer; Opsopoeodus megalops* Forbes is synonymous with *O. emiliæ; Eupomotis euryorus* McKay is a hybrid between *E. gibbosus* and *Apomotis cyanellus*, and the introduced tench (*Tinca*) has disappeared from our waters.

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*Contribution No. 102 from the Department of Zoology and Entolomology, the Ohio State University.

The increase in the list is accounted for in two ways: First, more extensive collecting has added *Petromyzon marinus*, *Clinostomus vandoisulus*, *Notropis anogenus*, *Notropis dorsalis*, *Phenacobius mirabilis*, *Schilbeodes nocturnus*, *S. furiosus*, *Microperca punctulata*, and *Cottus ricei.* Second, more careful taxonomic study, especially by Dr. C. L. Hubbs of the University of Michigan Museum, has resulted in the separation of former species into two or more. Thus a new black bass, *Micropterus pseudaplites* has been separated from the Smallmouth; the river chub (*Hybopsis kentuckiensis*) has been split into three species, two of which occur in the state; the suckers of the genus *Moxostoma* have been restudied and we now have six species instead of three, etc.

The nomenclature has undergone much revision during the past few years and many of the names now in use are recognizable only to the taxonomist. It is hardly possible that such a tangled synonomy is even yet straightened out. In the following list the authors have followed closely the work of Dr. Hubbs who has checked many of our determinations of the species. Where changes have been made in the list here presented, those of Osburn's "Fishes of Ohio" appear in parenthesis.

Except for additions to the list no occurrence records are noted, for the reason that it is proposed to issue a complete report in which will be brought together our extensive data on distribution, ecology, food, breeding and other phases of ichthyological investigation.

List of the 159 Species and Subspecies Known to Occur in Ohio.

Family Petromyzonidæ. Lampreys.

Petromyzon marinus L. Lake Erie, near West Sister Island, Nov. 14, 1927, collected by W. M. Tidd. This lamprey has been reported for Lake Erie, but not in Ohio waters.
Ichthyomyzon concolor (Kirtland).
Lampetra lamotteni (LeSueur). (*L. wilderi* Gage).

Family Acipenseridæ. Sturgeons.

Acipenser fulvescens (Rafinesque). (*A. rubicundus* LeSueur).
Scaphirhynchus platorhynchus (Rafinesque).

Family Polyodontidæ. Paddlefishes.

Polyodon spathula (Walbaum).

Family Lepisosteidæ. Gar pikes.

Lepisosteus osseus (L)
Lepisosteus platostomus (Rafinesque).
Lepisosteus tristoechus Bloch and Schneider.

Family Amiidæ. Bowfins.

Amia calva L.

Family Hiodontidæ. Mooneyes.

Hiodon tergisus LeSueur.
Amphiodon (Hiodon) alosoides Rafinesque.

Family Clupeidæ. Herrings.

Pomolobus chrysochloris Rafinesque.

Family Dorosomidæ. Gizzard shads.

Dorosoma cepedianum (LeSueur).

Family Salmonidæ. Salmons and Trouts.

Salmo fario L. Brown Trout. Introduced and established in Castalia Creek.

Salmo irideus Gibbons. Rainbow trout. Introduced into Castalia Creek, Lake Erie drainage and head waters of Mad River, Ohio drainage. Adults, probably escaped, have been taken at a number of places in the west end of Lake Erie and in the Huron River near the lake.

Cristivomer namaycush (Walbaum).
Salvelinus fontinalis fontinalis (Mitchill).

Family Coregonidæ. Whitefishes.

Coregonus clupeaformis (Mitchill).
Leucichthys artedi artedi (LeSueur). (*Argyrosomus artedi*).
Leuchichthys artedi albus (LeSueur). (*Argyrosomus tullibee* Richardson).

Family Catastomidæ. Suckers.

Megastomatobus (Ictiobus) cyprinella (Cuvier and Valenciennes).
Ictiobus niger (Rafinesque). (*I. urus* Agassiz).
Ictiobus bubalus (Rafinesque).
Carpiodes carpio (Rafinesque).
Carpiodes velifer (Rafinesque). (*C. difformis* Cope).
Carpiodes cyprinus (LeSueur). (*C. velifer* Rafinesque and *C. thompsoni* Agassiz).
Cycleptus elongatus (LeSueur).
Catostomus commersonnii commersonnii (Lacepede).

Catostomus catostomus (Forster). Jordan's Ohio Report states that this fish is "quite abundant in Lake Erie," but we have not seen it nor have other collectors noted its presence. Was the record an error or has the fish disappeared from Lake Erie?

Hypentelium (Catostomus) nigricans (LeSueur).

Erimyzon sucetta kennerlii (Girard). (*E. sucetta oblongus* Mitchill, part). The typical sweet sucker of the lakes.

Erimyzon oblongus claviformis (Girard). (*E. sucetta oblongus*, part.) The common stream form.

Minytrema melanops (Rafinesque).

Moxostoma rubreques Hubbs. Represented in our collections by one specimen from the Ohio River drainage, a paratype deposited in the Museum of the University of Michigan.

Moxostoma erythrurum (Rafinesque). (*M. aureolum* LeSueur, part). The commonest of the "redhorse" suckers, in most of the creeks and rivers of both drainages and occasionally in lakes.

Moxostoma aureolum (LeSueur). (*M. breviceps* Cope). The common short-headed sucker of Lake Erie.

Moxostoma breviceps (Cope). (*M. aureolum* part. Not the *M. breviceps* of Osburn's list). A short-headed sucker of the Ohio River drainage only.

Moxostoma duquesnii (LeSueur). (*M. aureolum*, part. Not the *Placopharynx duquesnii* of Osburn's list). Well distributed over the state but not commonly taken.

Moxostoma anisurum (Rafinesque).

Placopharynx carinatus Cope. (*P. duquesnii* LeSueur).

Lagochila lacera Jordan and Brayton.

Family CYPRINIDÆ. Minnows.

Cyprinus carpio L. Carp. Introduced everywhere.

Carassius auratus (L.). Goldfish. Introduced and very abundant in Lake Erie, inland lakes and larger streams.

Nocomis biguttatus (Kirtland). (*Hybobsis kentuckiensis* Raf., part). Especially in Northern Ohio on weedy ripples.

Nocomis micropogon (Cope). (*Hybopsis kentuckiensis*, Raf., part). All over the state, but does not frequent weedy places.

Erimystax (Hybopsis) dissimilis (Kirtland).

Extrarius (Hybopsis) hyostomus (Gilbert).

Hybopsis storerianus (Kirtland).

Hybopsis amblops (Rafinesque).

Rhinichthys atronasus meleagris Agassiz (*R. atronasus* Mitchill, part).

Rhinichthys atronasus obtusus Agassiz. (*R. atronasus* Mitchill, part).

Rhinichthys cataractæ (Cuvier and Valenciennes).

Semotilus atromaculatus atromaculatus (Mitchill).

Clinostomus vandoisulus (Cuvier and Valenciennes). Churn Creek, Adams County, April 20, 1929, and Lapparell Creek, Pike County, July 28, 1929, both records by Trautman. The latter is the most northerly record known.

Clinostomus (Leuciscus) elongatus (Kirtland).

Opsopoeodus emiliæ Hay. (Includes *O. megalops* Forbes).

Notropis heterodon (Cope).

Notropis anogenus Forbes. First taken in Ohio by C. Rutter at Port Clinton and Lakeside, 1898. Rediscovered by Osburn in Catawba Island "harbors" in 1929, though a specimen taken by Trautman

in Lake Erie at Port Clinton in 1927 has been found in a collection at the Ohio State Museum. The species is apparently limited to the shallow weedy waters adjacent to Lake Erie.

Notropis atrocaudalis heterolepis Eigenmann and Eigenmenn (*N. cayuga*, part).

Notropis atrocaudalis atrocaudalis Evermann (*N. cayuga*, part).

Notropis volucellus volucellus (Cope). (Includes also some of Osburn's *N. blennius*). It is the common variety over the state.

Notropis volucellus buchanani Meek. Larger streams of the extreme southern part of the state.

Notropis deliciosus missuriensis (Cope). (*N. blennius*, part). This variety has a more westward distribution but enters Ohio through the Maumee system into the western end of Lake Erie and also occurs in south-western Ohio, in more or less typical form.

Notropis deliciosus stramineus (Cope). (*N. blennius*, part). General throughout the state, but most typical in the eastern and north-eastern portions.

Notropis boops Gilbert. (*N. shumardi* Girard).

Notropis dorsalis dorsalis (Agassiz). First taken by Wickliff in Black River, Loraine County, August 7, 1922. Later records by Trautman, Hine and Walker in Cuyahoga, Medina and Summit counties.

Notropis blennius (Girard). (*N. jejunus* Forbes).

Notropis hudsonius hudsonius (Clinton).

Notropis whipplii spilopterus (Cope). (*N. whipplii* Girard).

Notropis ariommus (Cope).

Notropis atherinoides Rafinesque.

Notropis photogenis (Cope). (*N. arge* Cope).

Notropis rubellus (Agassiz). (*N. rubrifrons* Cope).

Notropis cornutus chrysocephalus (Rafinesque). The dominant subspecies, found practically over the whole state.

Notropis cornutus frontalis (Agassiz). Only in the coldest, most northerly situations in the state, especially the small, cold, hill streams of eastern and north-eastern Ohio.

Notropis umbratilis cyanocephalus (Copeland). (*N. u. lythrurus* Jordan, part). The only "redfin" found in the lake drainage. It also occurs in the northern part of the Ohio River drainage.

Notropis lythrurus (Jordan). (*N. u. lythrurus*, part). This species occurs in the south western part of the state. In previous reports it was confused with the preceding.

Ericymba buccata (Cope).

Phenacobius mirabilis (Girard). First taken by Osburn and Wickliff at Lake St. Marys, July 26, and in Big Walnut Creek, September 9, 1920. Later Wickliff and Trautman have found it not uncommon in the western half of the state, especially in the Scioto and Maumee systems.

Exoglossops lauræ Hubbs (MSS.) (*Exoglossum maxillingua* LeSueur). This species, first recorded in Osburn's report has been separated from Exoglossum and made a new genus and species by Hubbs. It has been taken again near the place where Osburn found it.

Notemigonus (Abramis) crysoleucas crysoleucas (Mitchill).

Hybognathus nuchalis Agassiz.
Chrosomus erythrogaster erythrogaster Rafinesque.
Hyborhynchus (*Pimephales*) *notatus* (Rafinesque).
Pimephales promelas Rafinesque.
Hypargyrus velox Girard. (*Cliola vigilax* Baird and Girard).
Campostoma anomalum (Rafinesque).

Family AMEIURIDÆ. Catfishes.

Ictalurus furcatus (LeSueur).
Ictalurus punctatus (Rafinesque).
Villarius (*Ameiurus*) *lacustris* (Walbaum).
Ameiurus melas melas (Rafinesque).
Ameiurus nebulosus (LeSueur).
Ameiurus natalis (LeSueur).
Pelodictis limosus Rafinesque. (*Leptops olivaris* Rafinesque).
Noturus flavus Rafinesque.
Schilbeodus gyrinus (Mitchill).
Schilbeodes nocturnus (Jordan and Gilbert). Recorded from a single specimen taken by Wickliff in Ottawa County, near the mouth of the Portage River, June 27, 1929. This is the first record of the species from the Great Lakes drainage.
Schilbeodes furiosus (Jordan and Jenkins). Taken by Trautman, July 3, 1927, in Shade Creek, Meigs County, and in the lower reaches of the Scioto and Muskingum rivers in 1929. Formerly known only from the Neuse, Tar and Little rivers of North Carolina, the species has also recently been noted for Indiana and Michigan by Hubbs.
Schilbeodes miurus (Jordan).
Schilbeodes eleutherus (Jordan).

Family UMBRIDÆ. Mud Minnows.

Umbra limi (Kirtland).

Family ESOCIDÆ. Pikes.

Esox (*Lucius*) *vermiculatus* LeSueur.
Esox (*Lucius*) *lucius* L.
Esox (*Lucius*) *masquinongy masquinongy* (Mitchill). (Part, L. Erie drainage).
Esox (*Lucius*) *masquinongy ohiensis* Kirtland. (Part, Ohio River drainage).

Family ANGUILLIDÆ. Eels.

Anguilla bostoniensis (LeSueur). (*A. chrysypa* Rafinesque).

Family CYPRINODONTIDÆ. Killifishes.

Fundulus diaphanus menona (Jordan and Copeland).
Fundulus dispar (Agassiz).
Fundulus notatus (Rafinesque).

Family PERCOPSIDÆ. Trout Perches.

Percopsis omiscomaycus (Walbaum). (*P. guttatus* Agassiz).

Family APHREDODERIDÆ. Pirate Perches.

Aphredoderus sayanus (Gilliams).

Family MORONIDÆ. White Basses.

Lepibema (*Roccus*) *chrysops* (Rafinesque).

Family PERCIDÆ. Perches.

Perca flavescens (Mitchill).
Stizostedion canadense canadense (Smith). (*S. c. griseum* DeKay).
Stizostedion vitreum (Mitchill). (*S. vitreum*, part).
Stizostedion glaucum Hubbs. (*S. vitreum*, part). The blue pike-perch of Lake Erie, especially in the eastern part of the lake.

Family ETHEOSTOMIDÆ. Darters.

Hadropterus evides (Jordan and Copeland).
Hadropterus maculatus (Girard). (*H. aspro* Cope and Jordan).
Hadropterus phoxocephalus (Nelson).
Hadropterus scierus Swain.
Percina caprodes caprodes (Rafinesque).
Percina caprodes semifasciata (DeKay) (*P. c. zebra* Agassiz). In the most typical form only in Lake Erie.
Cottogaster copelandi (Jordan).
Imostoma (*Cottogaster*) *shumardi* (Girard).
Ammocrypta pellucida (Baird).
Crystallaria asprella (Jordan).
Boleosoma nigrum nigrum (Rafinesque).
Poecilichthys (*Etheostoma*) *variatus* Kirtland.
Peocilichthys (*Etheostoma*) *camurus* Cope.
Peocilichthys (*Etheostoma*) *zonalis* Cope.
Peocilichthys (*Etheostoma*) *coeruleus* (Storer).
Pcocilichthys spectabilis (Agassiz). (*Etheostoma coeruleus spectabile*).
Peocilichthys (*Etheostoma*) *tippecanoe* Jordan and Evermann.
Peocilichthys exilis (Girard). (*Boleichthys fusiformis* Girard).
Catonotus (*Etheostoma*) *flabellaris flabellaris* (Rafinesque).
Microperca punctulata Putnam. First taken by Wickliff and Osburn in Turkeyfoot Lake, August 7, 1920; and later by Trautman in Blue Creek, Erie County and Nettle Lake, Williams County.
Etheostoma (*Diplesion*) *blennioides* Rafinesque.

Family CENTRARCHIDÆ. Black Basses and Sunfishes.

Micropterus dolomieu Lacepede. (Part).
Micropterus pseudaplites Hubbs. This recently described species, the "Kentucky Black Bass," separated from the preceding, is found to be the dominant Bass of the rivers of extreme southern Ohio, taken in about 18 counties, where it prefers the quieter waters.

Aplites (*Micropterus*) *salmoides* (Lacepede).
Chaenobryttus gulosus (Cuvier and Valenciennes).
Apomotis cyanellus (Rafinesque).
Helioperca incisor (Cuvier and Valenciennes). (*Lepomis pallidus* Mitchill).
Xenotis (*Lepomis*) *megalotis megalotis* (Rafinesque Part).
Xenotis (*Lepomis*) *megalotis peltastes* (Cope). This subspecies occurs in the lake drainage of Ohio.
Allotis (*Lepomis*) *humilis* (Girard).
Eupomotis heros (Baird and Girard).
Eupomotis gibbosus (L.).
Ambloplites rupestris (Rafinesque).
Pomoxis annularis (Rafinesque).
Pomoxis sparoides (Lacepede).

Family ATHERINIDÆ. Silversides.

Labidesthes sicculus Cope.

Family SCIAENIDÆ. Croakers, Drumfishes.

Aplodinotus grunniens Rafinesque.

Family COTTIDÆ. Sculpins.

Cottus bairdii bardii Girard. (*C. ictalops* Rafinesque).
Cottus ricei Nelson. A single specimen by Wickliff and Tidd in Lake Erie, near Kelley's Island, November 7, 1928. It is common farther east in the deeper waters of the lake.

Family GASTEROSTEIDÆ. Sticklebacks.

Eucalia inconstans (Kirtland).

Family GADIDÆ. Codfishes.

Lota maculosa (LeSueur).

TWO OHIO SUBTERRANEAN ASCOMYCETES AND THEIR ASCOMYCETOUS PARASITES.*

W. G. STOVER AND M. M. JOHNSON.

The genus Cordyceps is of considerable interest to mycologists and to other naturalists. Most of the species are parasites of insects, the fruiting bodies developing on the larval or pupal stages, and in some species on the adult stage, of the insect (5, 6). The species most commonly found is *C. militaris* (L.) Link which occurs on buried pupæ and larvæ. The writers, and others, have collected it in Ohio several times in recent years. The fruiting body is a slender, firm but fleshy structure, one to two inches tall and orange-yellow in color. The upper portion is covered with pimple-like papillæ which mark the position of the embedded perithecia containing the numerous asci, each with its eight slender ascospores. The genus is placed in the pyrenomycetous order, Hypocreales.

There are two species of Cordyceps, however, which are parasitic on certain fungi belonging to the genus Elaphomyces. The species of Elaphomyces are all subterranean. The mycelium of some of them forms mycorrhizas with the roots of coniferous trees, species of pine being most frequently mentioned. Dodge (1), in his recent monograph, lists 24 known species, of which he reports eight to occur in America with an additional doubtful record. Only two of these, *E. muricatus* Fr. (from Michigan) and *E. variegatus* Vitt. (from Iowa), have been reported from the north central states.

The fruiting body of the species of Elaphomyces is more or less globose and covered with a relatively thick rind of three distinct layers: The *crust* or outer layer, the *cortex* or middle layer and the *peridium* or inner layer. The spores are borne in asci which occur in scattered groups throughout the central portion of the fruiting body. The asci disappear after the spores are formed and the mature fructification is more or less completely filled with a brown powdery mass of spores. This genus is included in the order Aspergillales of the Plectomycetæ.

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While collecting fungi in the deep ravine below Old Man's Cave in Hocking County, Ohio, on August 15, 1925, the writers found a specimen of clavate Cordyceps. Upon removing it from the soil, it was discovered to arise from a globose subterranean fungus having much the appearance of a golf ball except as to color. This was later determined as *Elaphomyces variegatus* Vitt. The next day about a dozen other specimens of this species were found in the same ravine on a rock ledge covered with well-decayed leaf mold. Other collections have been made since as recorded below.

On October 9, 1926, a capitate Cordyceps was collected near Sugar Grove, Fairfield County, Ohio. This specimen developed from the buried fruiting body of another species of Elaphomyces which was later determined as *E. anthracinus* Vitt. After taking field notes on these collections, the specimens were preserved in 7% formaldehyde, and later studied more fully in the laboratory.

These collections are of particular interest because, so far as we have been able to learn, none of the species has been previously reported for this region. *E. anthracinus* has been reported in America only from Tennessee and North Carolina; *E. variegatus* is here recorded from the Ohio Valley for the first time, while neither of the species of Cordyceps has hitherto been reported west of the Alleghenies. The ranges of all four of the species discussed is therefore considerably extended.

Elaphomyces variegatus Vitt.

The fruiting body is subterranean; globose, subglobose or somewhat flattened; 1-3 cm. in diameter; yellowish-brown, and covered with warts of the same color. The warts are about as broad as high and rounded at the tips. Their bases are mostly pentagonal or hexagonal, although the smaller ones are often triangular. The peridium is quite thick and firm, and brownish-rose in color. In sections of the peridium there are reddish-brown reticulations plainly to be seen throughout its thickness. No asci were found in any of the specimens examined, but the characteristic dark-brown ascospores were quite abundant, filling the whole interior. According to our measurements the spores are 18-21 microns in diameter.

Our specimens were found in well-decayed leaf mold, two to four inches beneath the surface, in a damp ravine at Old Man's Cave, Hocking County, Ohio; Stover and Johnson, August 15, 16, 1925; Johnson and Dobbins, August 29, 1926; Stover, Johnson and Humphrey, September 10, 1927.

This was at first assumed to be *E. cervinus* (L.) Schlecht., probably the most common species of the genus, and frequently referred to in the literature as *E. granulatus* Fr. After microscopic examination, however, our specimens were determined to be *E. variegatus* Vitt. as interpreted by Dodge (1). In both species, the "crust" or outer mycelial layer, is readily separated and therefore not usually seen. The peridium, or inner layer of the rind, is markedly different in the two species, however. In *E. variegatus*, it is described as being grayish-rose to chestnut in color and "marbled with reddish-brown reticulations." In *E. cervinus* the peridium is white and without reticulations. The spores of the latter species are considerably larger, measuring 26-30 microns in diameter. Our specimens agree with Dodge's description of *E. variegatus* in all essential respects. He does not mention the triangular bases of the smaller warts and we were not able to demonstrate a "yellow gel" surrounding the warts, perhaps on account of the preservation of the specimens in formaldehyde.

According to Dodge, *E. variegatus* has previously been collected in southern Europe, New England, Florida and Iowa. Lewton-Brain (3) studied material collected in Scotland. He, as well as others, states that it forms a mycorrhiza with the roots of pine and other conifers. No observations were made by the writers on this point, but hemlock trees were growing near the place of collection and it is quite possible that a mycorrhizal relation had been established between the mycelium of the fungus and the roots of the hemlock. The yew (*Taxus canadensis* Marsh) also occurs in that part of the ravine, while two species of Pinus grow on the hills just above the ravine.

Most of these specimens were parasitized by *Cordyceps parasitica* (Willd.) Seaver which is described below. In fact the latter fungus was seen first and the Elaphomyces was found only upon removing the Cordyceps from the soil. A few of the fruiting bodies had no parasites attached.

Elaphomyces anthracinus Vitt.

The fruiting body is subterranean, globose, about 1.3 cm. in diameter and dark brown to black in color. The outer layer, the crust, is readily separated from the hard, fragile, carbonaceous cortex. The peridium, or inner layer of the rind is thick, white, with a dark line near the middle, and cottony in texture. The interior is filled with the dark spore-bearing portion. No asci were found in our specimen. The spores

are brown to dark brown, globose, 15-20 microns in diameter according to our measurements. The outer surface is often thickly studded with fine points or prickles.

This species was collected by the writers at Sugar Grove, Fairfield County, Ohio, October 9, 1926. The single plant was found in a damp ravine, about two inches beneath the surface of well-decayed leaf mold. There are hemlock trees in the immediate vicinity and pines on the hill just above the ravine. The specimen agrees very well with Dodge's (1) description of *E. anthracinus*. Our plant was parasitized by *Cordyceps agariciformia* (Bolt.) Seaver, which is described below.

Although apparently fairly common in central and southern Europe, this species has been previously reported in this country only from Tennessee and North Carolina, according to Dodge (l. c.)

Cordyceps parasitica (Willd.) Seaver.

The fruiting body or stroma consists of a cylindrical stalk and a club-shaped fertile portion or head. The whole fruiting body becomes very dark brown or black. In some of our specimens the stalk or its base was deep yellow or golden-orange when collected but became black later. The head is somewhat broader than the stalk; usually compressed laterally, but sometimes nearly circular in cross section; when compressed, usually narrowly elliptical in outline; rounded at the apex and narrowed gradually toward the stalk; 1.5-2.5 cm. high and 3-9 mm. across; clearly differentiated from the stalk, and covered with numerous small papillæ which mark the position of the ostioles of the embedded perithecia.

The stalk is slender, usually cylindrical, nearly smooth or sometimes longitudinally striate under the lens; 2.5-9 cm. long and 2-4 mm. in diameter; apparently branching at the base into a several root-like mycelial strands or rhizomorphs which extend through the soil and are attached to fruiting bodies of *Elaphamyces variegatus* Vitt.

The ascospores are filiform and nearly as long as the slender ascus which contains them; many-septate, at maturity breaking up into segments only slightly longer than broad.

Our plants were parasitic on fruiting bodies of *Elaphomyces variegatus* Vitt. in a damp ravine at Old Man's Cave, Hocking County, Ohio: Stover and Johnson, August 15, 16, 1925; Johnson and Dobbins, August 29, 1926; Stover, Johnson and Humphrey, September 10, 1927; Stover and Miller, October 12, 1929.

This fungus occurs in Europe and, as recorded by Seaver (5, 6), its American distribution is "Ontario to Rhode Island and Virginia."

C. parasitica is quite similar in appearance, size, shape and color to certain species of the Geoglossaceæ, but is readily distinguishable on account of the pimple-like papillae covering the upper portion of the fruiting body.

This species and the following are the only members of the genus Cordyceps known to occur as parasites on fungous fruiting bodies. Lloyd (4) points out that these two species differ not only in the shape of the fruiting body (stroma) but also in their method of attachment to their hosts, and in the character of the ascospores. In our specimens of *C. parasitica* the mycelial strands are a prominent feature. They are much branched and sometimes several centimeters long. When fresh they were deep yellow but became very dark brown or black after preservation. This fact, with other observations on the color, recorded above, leads us to believe that the whole fruiting body is probably yellow to orange when young.

Cordyceps agariciformia (Bolt.) Seaver.

The fruiting body or stroma in our specimen is 7 cm. tall and consists of a sterile stalk and a cap-like head or fertile portion. The ovoid head was about 1 cm. in diameter, yellowish below to brown and blackish above and somewhat shining when fresh. The entire surface of the head is covered with numerous papillæ which contain the ostioles of the embedded perithecia. The stalk was yellow when fresh but the whole plant is black since being preserved. The stalk is 5 mm. in diameter at the base, tapering somewhat toward the apex, smooth below and somewhat scaly above. The asci are slender and cylindrical; the ascospores are filiform, nearly as long as the ascus and are said to break up into rather long segments when mature.

This species was collected by the writers October 9, 1926, at Sugar Grove, Fairfield County, Ohio. The single specimen found was parasitic on *Elaphomyces anthracinus* Vitt., developing directly upon it without any mycelial strands such as those found in *C. parasitica* (Willd.) Seaver. It will be noted that the stalk and lower part of the head were yellow or yellowish when collected and later became black. It seems probable that the head, although black in our specimen when collected, is at first some shade of yellow. Seaver (5, 6) however, states that it is reddish-brown. The distribution, as recorded by

Seaver (l. c.) is "Maine to Ontario and Florida." Lloyd (4) and Hard (2) discuss and illustrate the fungus under the name *C. capitata* (Holmsk.) Link, formerly often used.

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PHYSICS AS A CULTURAL SUBJECT.*

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The traditional attitude of the physicist toward cultural courses in general and a cultural course in physics in particular has been one of relative indifference. Not that he has disclaimed any desire for culture, but he has regarded culture as a by-product to be obtained while seeking something more worth while. He has associated "cultural" with courses that are decidedly weak in content—for example, in physics non-mathematical descriptive courses. Among his other objections to a course for which nothing better could be said than that it is "cultural" has been that the word "cultural" does not admit of the rigorous definition that he has been accustomed to apply to his concepts. It is subjective, while he has regarded his interests as essentially objective. However recent developments in physics have obliterated what was formerly considered to be the sharp boundary between the objective and the subjective. Other developments have made him a little less certain of the absolute character of his knowledge. With these realizations—though perhaps independently—has come a more human point of view. A physics department head in a prominent university recently deplored the fact that physics made so small a contribution to the cultural development of the average undergraduate. Such concern would have been rare a few years ago. An undergraduate national physics fraternity has lately been sponsored by eastern physicists, one of the aims of which is to promote a greater appreciation of physics. Witness too the number of books that leading physicists have written for the layman since 1928. Evidently physicists are having increased interest in cultural considerations.

What then should be the proper criterion of the cultural course? It must be the degree to which it provokes thought and develops permanent interests rather than the degree of difficulty with which it is assimilated; the extent to which the

* An invited paper before the Physics Section of the Ohio Academy of Science, April 18, 1930.

student may be induced to work beyond the definitely assigned and formal tasks; and when he has finished the course and received his credit and grade does he forget it as he would a bad dream, or does it color the whole of his thinking; has the seeking of new knowledge on the subject become one of the avocations of his life; does it fortify leisure hours against dissipation. What study can compare with physics in these tests, yet how many students have left the subject of physics without being in the least impressed!

Of what does the cultural course in physics consist? It is not a compendium of facts. Facts attain cultural value only as they become materials for thought. The student in the cultural course must be given ample exercise in the manipulation of the facts he has learned. Now the ideas in physics are essentially mathematical, and before the student can do any constructive thinking in the subject, he must have at least some working knowledge of mathematics. A purely descriptive course is then ruled out. In such a course he can only give back parrot-fashion the facts he has heard or read, lacking even the ability to evaluate them. For a similar reason a popular demonstration course must be rejected, as well as for the additional reason that no physicist can compete with a magician in making a spectacular exhibition. Is the cultural course then rigorously mathematical? In no case would general physics taught on an exclusively mathematical basis have the highest cultural value. The function of the mathematics is that of a skeleton in holding vital elements together. The application of the mathematical developments to the physical ideas must be brought out in innumerable ways. Many instructors omit numerous simple applications as being altogether obvious, but they are not obvious to the average student, and the cultural course must not lack appeal to the average student. Class demonstrations are of the utmost value in illustrating the physical significance of the mathematical formulae. The illustrations and demonstrations not only add to the student's interest, but they justify in his mind the introduction of the mathematics. But how deeply into mathematical methods the instructor should go probably has no objective answer. A course is not cultural for any student if a considerable portion of his study is in memorizing formulae which he does not comprehend. But for that matter neither would it be of great value to him as a technical student.

A physics professor in a state university said some years ago, "If college physics (by which he undoubtedly meant cultural physics) is to persist, it must divest itself of its mathematical formulation." We can see in this statement little if any foundation in fact. No one has ever questioned the permanence of mathematics as a cultural subject, and if the mathematical student can not be interested in physics and if the physics course does not create a desire to know mathematics even where none existed before, there is something wrong with the course and it ought to perish. The most common trouble in our opinion is that there is far too little mathematics in the physics course. Perhaps the department does not have sufficient mathematical prerequisites for its courses, and as a result the instructor is more or less apologetic in introducing the mathematics. Even with prerequisites in college mathematics, there are many necessary mathematical ideas which the student seldom learns in the mathematics department. One of these concepts is functionality. Few students entering college physics even after two years of college mathematics know how to build up an expression for the dependent variable in terms of the independent variables though they are told the laws governing the independent variables. A rigorous presentation of mechanics in the general course furnishes opportunity for a vast amount of drill in fundamental mathematical concepts, and for a great deal more in associating the abstract mathematics with the physical ideas. In the derivation of the formulae every assumption and every approximation must be clearly pointed out, and a sharp distinction made between the experimental and the theoretical bases. Considerable use of dimensional equations is highly profitable. Admitting that this portion of the work rates low culturally for many students—(cultural is subjective), the students must be made to learn this technique by any methods found to be effective. The ability to use has high cultural value though the *process* of learning it may be almost as lacking in cultural value as the *process* of learning the alphabet or of learning to read.

In many physics departments the inferior student receives small consideration, irrespective of whether the reason for his inferiority is inability, laziness, or deficient back-ground due to early lack of opportunity. Many of the latter group are highly deserving. A little investigation shows a rather large percentage of these students with deficient back-ground to be

science teachers in the public schools or even high schools. If we do nothing for them, we have ourselves to blame for the unsatisfactory teaching in the secondary schools of which we all complain, and the vicious circle will persist. Often it is impossible to give them a great deal of individual attention, but the introducing of each new subject by simple qualitative ideas is of the greatest value to these students. Furthermore this practice is not without value to the superior student in aiding him to connect up the familiar with the unfamiliar, and in no case, if the qualitative ideas are presented in a concise interesting way, is the attention of the superior student lost. There is on the other hand no place for sluggards and drones in the cultural physics course.

When the class has learned sufficient mathematical technique to use in a constructive way, the instructor may discard his driving methods, substituting therefor inspirational methods. Nor do these preclude giving in the general course such derivations as the equation of the adiabatic and Carnot's cycle. However the student must previously be given some comprehension of isothermal, adiabatic, and graphical representation of work, or he will have a mass of material that he can only memorize.

We have made the average student the determining factor in the presentation of the cultural course. But when his needs are given proper consideration, the whole class may be carried to greater heights, and hence this course is best for the superior student as well.

Something should be said concerning the qualifications of the teacher of the cultural course. In addition to the qualifications commonly emphasized, he should be interested in people and in the way in which their minds work. Fully realizing the mental deficiencies of his students, he needs endless patience in dealing with them, and he can use the zeal of a reformer.

Finally, the qualifications of the teacher of the cultural physics course and those of the course itself are the very ones that make it the most valuable for the technical student as well.

DRAINAGE CHANGES IN THE TOLEDO REGION.*

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Ohio State University.

GENERAL CHARACTERISTICS OF THE DRAINAGE.

The surface south of the west end of Lake Erie in Ottawa, Sandusky, Wood and Lucas counties is a very flat plain which slopes gently northeastward toward the lake at about 5 feet per mile. This plain is the old lake bed of Lake Erie extended, as it existed during the retreat of the Wisconsin glacial stage.

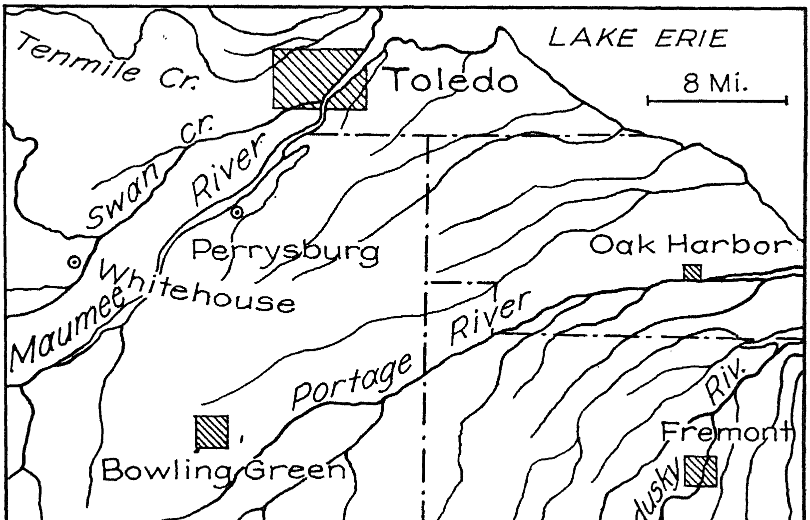

FIG. 1. Map of a portion of northwestern Ohio showing the closely-spaced, parallel, northeastward-flowing streams.

The drainage of the region is by closely-spaced, parallel, northeastward-flowing streams which originated as *consequent streams* on the flat plain as the Pleistocene, ice-border lake withdrew to the present Lake Erie (Fig.1). On this even surface, with very gentle but uniform slope, many of the

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originating streams flowed for great distances parallel with each other, without uniting, although only a mile or two apart.

The Maumee River, the major stream of the region, was formed along the axis of the old lake basin, chiefly by waters which entered the region from the west, but the floor of the median part of the basin had so little slope toward the axis that smaller streams originated and flowed northeast in the direction of the axis, parallel with, though only a short distance from, the far greater Maumee. At the time of the origin of the drainage, the Maumee received no tributaries from the northwest from the southwest corner of Lucas County northeast to its mouth, a distance of 30 miles, and no tributaries from the southeast north of Waterville, a distance of about 20 miles. The two streams which now join the Maumee within these intervals, Swan Creek on the northwest and Otter Creek on the southeast, are both interpreted here as cases of stream capture.

Swan Creek.

Swan Creek heads in Fulton County to the west and, in conformity with the general slope of eastern Fulton and western Lucas counties, flows southeast to near Whitehouse in southwestern Lucas County. Here, at about 3 miles from the Maumee River, it changes direction and flows northeast for about 15 miles parallel with the Maumee River which it joins at Toledo (Fig. 1). This lower, northeastward-flowing course of Swan Creek is a continuation of the course of South Swan Creek which enters at the bend near Whitehouse and these two parts together make a drainage course 25 miles long from the southeast corner of Fulton County to Toledo, parallel with and only 2 to 4 miles from the Maumee River.

A low linear course, occupied largely by a marsh, runs northeast from the Ann Arbor Railway Station on Cherry Street in Toledo to Maumee Bay, parallel with but definitely separated from the Maumee River by a narrow belt of upland one-half mile or less in width (Fig. 2). Its linear form, flat floor, and definite, bounding slopes show plainly that this low course was made by stream erosion but no stream competent to do the work occupies it now, or could have received sufficient water for the work from the few square miles tributary to this depression.

The interpretation offered is that Swan Creek did not formerly join the Maumee River at Toledo, but continued on northeast along this low course to an independent terminus at the head of Maumee Bay. Near the present mouth of

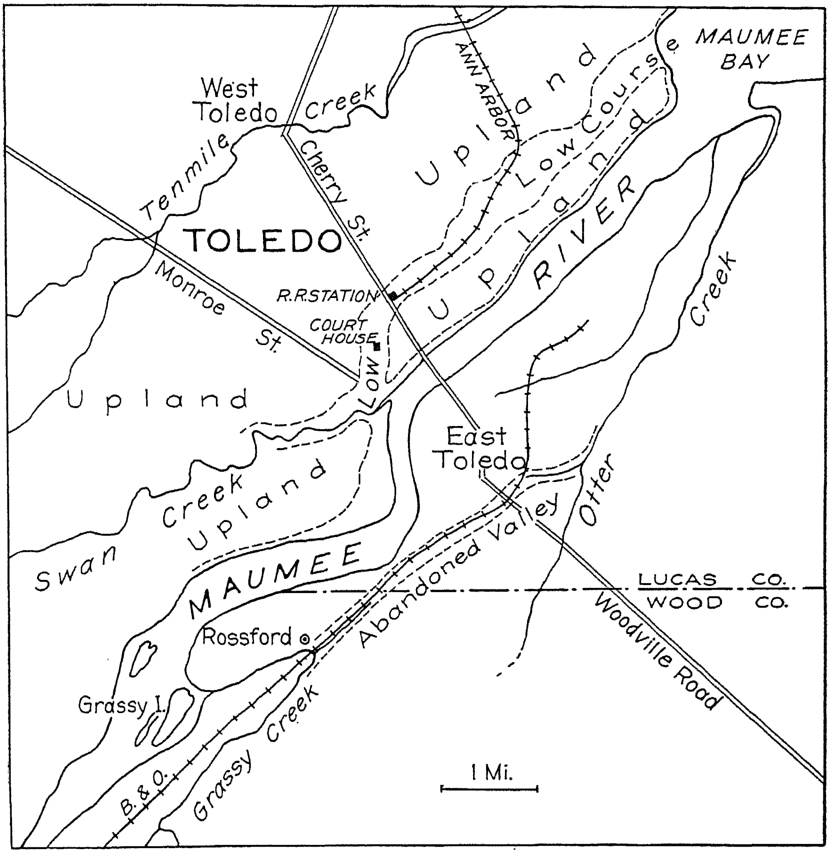

FIG. 2. Map of the Toledo region showing the drainage changes of Swan Creek and Grassy Creek as discussed in the text.

Swan Creek in Toledo the belt of upland between the two valleys was so narrow that the combined undercutting by the streams on the outer curves of loops opposite each other cut completely through the intervening divide and Swan Creek entered directly the larger stream, and thus abandoned its lower course northeast of Toledo (Fig. 2).

The former course of Swan Creek through the down-town part of Toledo is partly obscured by filling and grading but close observation shows definite topographic evidence to support the foregoing interpretation. The former course left the present Swan Creek near the St. Clair Street bridge and, continuing on northeast, crossed Monroe Street near Superior Street, crossed Madison Street near Erie Street, passed across the site of the Court House and the City Prison, and crossed Cherry Street at Seneca Street at the Ann Arbor Railway Station. This course leads through the down-town section of Toledo. It was formerly followed by the Miami and Erie canal. Northeast of Cherry Street the course is very definite as noted in the foregoing.

The points of the severed upland are shown on the south by the higher land that begins just south of the St. Clair Street bridge and on the north by the elevation which begins on Summit Street near Jefferson Street. Between these limiting points, about three-eighths of a mile apart, the undercutting of the divide between Maumee River and the former Swan Creek took place, resulting in the diversion of Swan Creek.

The particular type of stream piracy illustrated here by which two streams cut laterally until their valleys unite, is called *planation stream piracy.** The Maumee River was the *pirate*. Swan Creek is the *diverted stream*. That part of the former valley from Toledo to Maumee Bay that was left without a stream is an *abandoned valley*.

Grassy-Otter Creek.

Grassy Creek heads south of Perrysburg, Wood County, and flows northeast for about 7 miles parallel with, and only one mile or less from, the Maumee valley. Just southeast of Rossford the creek turns sharply to an acute angle of about 25 degrees and flows west-southwest for one and one-fourth miles, through a sharply cut valley, to the Maumee River, (Fig. 2). From the acute angle bend of Grassy Creek a low course, which is very evidently a stream-cut valley, continues on to the northeast through the south part of East Toledo and is occupied by the upper course of Otter Creek which enters Maumee Bay just east of the mouth of the Maumee River.

*1921. Malott, C. A. Planation Stream Piracy. Proc. Indiana Acad. Science, 1920, pp. 249–260.

From Rossford northeast through the south part of East Toledo this low course is followed by the Baltimore and Ohio Railway with extensive railway yards. In East Toledo, Navarre Park is located in this old valley. On northeast it is a distinct, flat-floored valley, much too large for Otter Creek which occupies it.

The existence of such a sharp angle bend, as that of Grassy Creek southeast of Rossford, suggests piracy, and the abandoned valley continuing northeast from the bend gives additional evidence. The interpretation offered is that Grassy Creek and Otter Creek were formerly one stream which originated on the gently sloping, lake plain and for 14 miles, from Perrysburg to the mouth of Otter Creek, had a course parallel with and only one-half to one and one-half miles from the Maumee River. A small tributary of this Grassy-Otter Creek headed within the area of the present Maumee valley at Grassy island and flowed northeast along the course of the present Grassy Creek reversed, joining Grassy-Otter Creek at the location of the present sharp angle of Grassy Creek. The Maumee River then cut laterally, forming the reentrant in which Grassy Island now lies, and in doing so it undercut that part of the plain containing the headwaters of the small tributary of Grassy-Otter Creek. The gradient of this tributary upon the plain was very low and some of its water at its undercut head flowed down the bluff of the Maumee valley and started a gully. Because of the much lower level of its mouth at the Maumee River, this gully had a far steeper gradient than the tributary of Grassy-Otter Creek and because it continually received water at its head from the valley of the tributary, it rapidly lengthened headward along the course of the tributary and, by a process which we may call *headwater piracy*, gradually reversed the direction of drainage of more and more of the tributary until the place of union of the tributary with Grassy-Otter Creek southeast of Rossford was reached. Here, the level of the head of the gully being below the level of Grassy-Otter Creek, the gully captured the creek and took its waters by the reversed course of its former tributary, west-southwest down the gully to the Maumee River.

The type of piracy illustrated here by which a rapidly eroding stream, like the gully, extends itself by *headword erosion* into the course of a more sluggish stream, like Grassy-Otter Creek, is known as *headword erosion piracy*. It is probably the most common type of piracy and is favored by

escarpments or steep bluffs, like those along the Maumee valley, in close proximity to streams which flow with gentle gradients upon a higher plain. In the geologic future many cases of this type of piracy should take place in the area bordering the

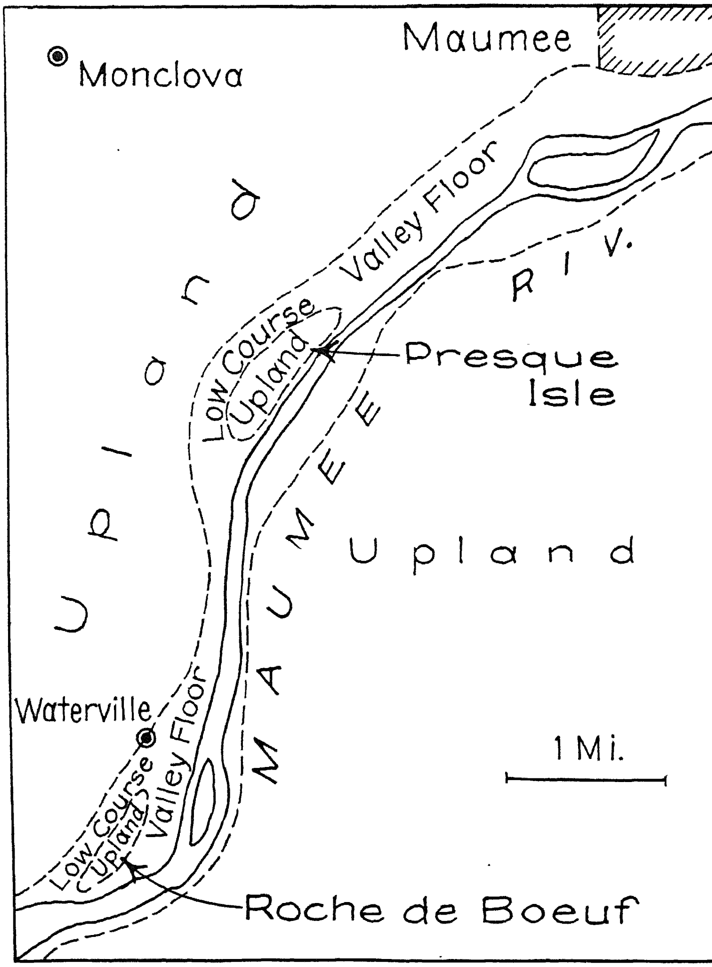

FIG. 3. Map of the Maumee River valley from Maumee southwest through Waterville showing the location of the island-like areas, Presque Isle and Roche de Boeuf, which are separated from the upland by low courses.

Maumee valley. The especial feature of this case is that the gully that did the capturing, the *pirate*, was apparently producing reversal of drainage by working headward along the course of a tributary of the stream which it finally captured.

Grassy Creek south of the sharp angle is the *diverted stream*. Otter Creek is the *beheaded stream*. The part of the former course for several miles northeast of the point of capture through the south part of East Toledo is an *abandoned valley* and the direction of drainage of the southern part of this abandoned course for at least a mile northeast of the place of capture has been reversed and now flows southwest.

Maumee River.

Three miles southwest of the village of Maumee there is, within the Maumee valley proper, an island-like elevation, known as Presque Isle, one mile long and less than one-fourth of a mile wide and rising to the level of the adjoining upland plain (Fig. 3). The river is on the east of Presque Isle in a rock channel, while on the west, Presque Isle is separated from the upland by an abandoned, flat-bottomed valley about one-fourth of a mile wide. The floor of this valley is on rock at 25 to 30 feet below the upland and about 20 feet above the river. Apparently the Maumee River lowered both valleys concurrently until the bed rock was reached when the valley on the east of Presque Isle acquired all the river and the valley on the west was abandoned.

A similar but smaller, elongate, island-like area which was known in an early day as Roche de Boeuf, exists in the Maumee valley south of Waterville at the north end of the Ohio Electric Railway bridge (Fig. 3). The abandoned valley on the west is followed here by the Miami and Erie canal. This is another case where the Maumee River cut a larger and smaller valley concurrently until the bed rock was reached when the larger valley on the east acquired the entire river.

A STUDY OF THE FOOD OF THREE FISH SPECIES FROM THE PORTAGE LAKES, OHIO.

HAROLD CASSIDY, ARTHUR DOBKIN, AND RALPH WETZEL.

INTRODUCTION.

By WALTER C. KRAATZ,
University of Akron.

During fish seining operations in the summers of 1926 and 1927, by the writer and assistants, many fishes, particularly minnows and other smaller types were secured from the Portage Lakes near Akron, Ohio.

Previously the writer published a paper on the food of the most abundant fish species of the lakes; (Kraatz: Study of the food of the blunt-nosed minnow, *Pimephales notatus*, Ohio Jour. Sci., Vol. XXVIII, No. 2, pp. 86–98, March 1928).

Food of any fish species of various localities is of interest in extending existing data on food habits, and it is thought desirable to publish food data on three other species from these lakes, but combined as one paper from the independent papers of the three student authors, to save repetition of introductions, etc. Discussion of details is largely omitted, as is a bibliography, which in this brief report is deemed superfluous. The methods of food study were the same standard methods employed in the above-mentioned paper in which they are sufficiently described.

Opsopoeodus emiliæ was the second most abundant minnow in the lakes during the collecting period, and Notemigonus (Abramis) crysoleucas was third. The "top minnow," *Fundulus diaphanus menona,* is of special interest because in this group of lakes it is found only in Turkeyfoot Lake, and in Ohio in general, only in the very northern part, and has been principally reported from Lake Erie bays and streams leading into them.

FOOD OF THE MINNOW *Opsopoeodus emiliæ.*

By HAROLD CASSIDY.

Only 32 specimens were studied, but the diets of these were so similar that they can be regarded as representative for these waters. Of these specimens 27 were from New Reservoir, 4 from Turkeyfoot Lake, and 1 from Nesmith Lake.

This minnow, (Table I), seems to have a preference for an animal diet as attested by the large number of Chironomidæ larvæ, Cladocera and Ostracoda ingested. The plant material may have been ingested largely as incidental material in the feeding. Noting the large number of midge larvæ eaten, a few were examined as to their food, and found to contain chiefly diatoms, Scenedesmus and some filamentous green algæ, all of which were likewise found free but in very small proportions in the minnow intestine. Opsopoeodus having principally an animal diet, more so than Pimephales notatus, is therefore more in competition with game fishes in their early stages. However no more than Pimephales does it in any way destroy young fishes in their early stages, and it also forms a link in the chain of converting plankton to a form available to the larger game fishes.

Food of the Golden Shiner
Notemigonus (Abramis) *crysoleucas.*

By Arthur Dobkin.

A series of 40 Portage Lakes specimens were studied, distributed as follows: New Reservoir, 34; East Reservoir, 4; Turkeyfoot Lake; 2.

This minnow, (Table II), seems to have preference for an animal diet. This is at least certain in specimens of the small size available from these particular waters, though it has been evident from other studies that considerable variability in food may exist. Cladocera formed by far the largest food type with Ostracoda second. In some cases Copepoda and in a few algæ were common. Thus it was feeding almost entirely on plankton, and only 4 specimens showed by inorganic debris ingested, a bottom feeding habit. The golden shiner is another good example of a fish suitable for converting plankton into food for larger game fishes.

Food of the Menona Top Minnow,
Fundulus diaphanus menona.

By Ralph Wetzel.

All specimens of the species collected were from Turkeyfoot Lake, and 40 were examined for food. These were all more than half grown and mostly mature. Many females carried eggs, and the intestinal contents in these were meagre. In one specimen virtually nothing was found.

It is of course apparent, (Table III), that this fish is a plankton feeder. Various Entomostraca formed outstanding food items, and in a very large number of cases, Amphipoda were prominent. The latter was the genus Hyalella so common in these waters, mostly on vegetation just a little submerged in shallow water. Very little phytoplankton was eaten, and in these specimens at least the food is principally larger animal plankton.

TABLE I.

Opsopoeodus emiliæ.

Percentage Composition of Alimentary Canal Contents.

Locality	Date	Length of Fish, mm.	Length of Intestine, mm.	Degree Filled	Inorganic	Plant Debris	Blue-green algae	Diatoms	Desmids	Scenedesmus	Green algae	Higher Plant Remains	Statoblasts of Bryozoa	Copepoda	Cladocera	Ostracoda	Chironomid Larvae	Insect Eggs	Insects (Various)	Animal Debris
New Reservoir	7/15/26	47	27	.25	5	2	1	1	....	1	1	....	....	....	30	5	50	....	....	4
	"	50	33	.20	1	9	1	1	1	1	1	....	....	....	5	....	60	....	....	20
	"	51	25	.25	1	....	1	1	....	2	1	....	....	....	4	....	30	....	60	....
	"	48	40	.25	1	....	1	1	1	1	3	....	....	....	2	....	65	....	....	25
	"	51	25	.15	1	....	1	1	1	1	1	1	....	....	....	....	50	....	....	43
	"	45	34	.15	4	....	1	1	....	1	1	....	....	....	2	....	60	....	....	30
	"	52	27	.15	1	....	1	1	....	1	1	....	....	....	10	....	....	....	....	85
	7/22/26	50	30	.50	....	12	....	1	....	1	1	....	....	....	5	10	20	5	....	45
	"	50	30	.50	1	5	1	1	....	1	1	....	....	....	....	5	40	....	....	45
	"	53	30	.60	....	10	....	1	....	1	2	....	....	....	....	....	40	1	....	45
	"	56	29	.25	....	....	....	1	....	1	1	....	....	....	3	5	70	....	....	19
	"	55	35	.33	....	1	....	1	....	1	2	....	....	....	11	....	70	....	....	15
	"	45	30	.85	....	....	....	....	....	....	....	....	....	....	80	7	3	....	1	9
	"	46	25	.75	....	....	....	....	....	....	....	....	....	....	1	1	20	....	70	8
	"	49	27	.60	....	7	....	1	....	2	15	....	....	....	....	....	70	....	....	5
	"	45	35	.90	....	2	....	1	....	1	1	....	....	....	35	5	55	....	....	....
	"	44	24	.50	....	....	....	1	....	1	....	....	....	....	20	8	60	....	5	5
	"	50	25	.0	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	"	46	26	.75	....	2	1	1	....	1	....	....	....	....	....	....	35	10	....	50
	7/29/26	48	27	.20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	"	48	26	.20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	100
	"	46	22	.60	....	....	1	....	....	....	1	....	....	....	....	40	25	....	....	....
	"	55	33	.40	....	....	5	1	....	....	5	....	....	....	5	4	....	....	....	80
	"	49	23	.40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	100
	"	48	32	.30	....	10	5	1	....	....	4	....	....	10	45	....	10	....	....	15
	"	50	25	.15	....	10	....	....	....	....	....	....	....	10	35	5	....	....	....	40
	"	46	20	.35	....	15	....	....	....	....	....	....	....	....	25	....	25	....	....	35
Turkey Foot Lake	7/24/26	46	38	.65	....	....	5	....	....	....	....	....	....	....	95	....	....	....	....	....
	"	45	31	.30	....	47	....	....	....	1	....	....	....	....	....	....	5	....	....	47
	"	40	26	.75	....	....	2	1	....	....	....	35	....	....	55	....	2	....	....	5
	"	44	29	.65	....	....	2	1	....	....	20	10	....	....	31	....	....	....	30	6
N*	7/6/26	49	11	.25	20	....	....	....	....	....	10	....	20	....	10	....	....	20	....	20

*Nesmith Lake.

TABLE II.

Notemigonus crysoleucas.

Percentage Composition of Alimentary Canal Contents.

Locality	Date	Length of Fish, mm.	Length of Intestine, mm.	Degree Filled	Inorganic	Plant Debris	Blue-green algae	Diatoms	Desmids	Filamentous Green algae	Statoblasts of Bryozoa	Copepoda	Cladocera	Ostracoda	Chironomid Larvae	Other Insects	Animal Debris
East R.	7/3/26	42	37	.50	3	....	5	....	....	....	....	....	....	90	....	....	2
	"	42	31	.25	1	90	....	....	....	3	....	5	....	....	....	....	1
	"	44	48	.25	2	....	2	....	....	4	....	....	....	87	....	....	5
	"	40	33	.66	5	5	1	....	....	1	....	....	....	86	....	....	2
New Reservoir	7/15/29	29	21	.75	....	....	3	....	....	2	....	....	90	5	....	....	....
	"	30	23	.50	1	....	....	....	....	....	....	....	32	35	....	30	2
	"	32	23	.66	5	....	....	....	....	....	....	....	90	....	....	....	5
	"	32	25	.75	....	....	....	1	....	1	....	....	90	....	....	8	....
	"	33	24	.75	....	....	....	....	....	1	....	4	30	15	....	50	....
	"	33	25	.50	....	2	....	1	....	....	....	....	70	....	....	27	....
	"	33	29	.50	....	....	....	....	....	2	5	....	85	2	....	1	5
	"	33	27	.75	....	....	....	1	....	1	....	....	75	18	....	....	5
	"	34	24	.33	....	....	....	2	....	1	....	....	90	7	....	....	....
	"	34	25	.50	3	....	....	1	....	....	....	....	90	....	....	3	3
	"	35	30	.66	....	1	....	....	....	....	....	....	95	3	....	....	1
New Reservoir	7/22/26	34	30	.66	5	3	....	....	....	2	....	....	75	10	....	....	5
	"	35	31	.25	35	....	....	....	....	40	....	....	20	....	....	....	5
	"	37	35	.50	....	....	....	....	....	1	....	....	55	43	....	....	1
	"	37	30	.50	2	1	....	....	....	1	....	5	....	90	....	....	1
	"	37	31	.75	2	1	....	....	....	1	....	....	95	....	....	....	1
	"	37	33	.75	1	....	....	....	....	1	....	12	85	....	....	....	1
	"	38	35	.50	1	....	1	...	....	5	....	....	5	65	15	5	3
	"	38	32	.33	15	10	....	....	....	5	....	....	55	....	....	....	15
	"	38	37	.81	....	....	....	....	....	1	....	....	49	49	1	....	....
	"	38	32	.50	1	....	....	....	....	1	....	....	95	3	....	....	....
	"	38	32	.66	1	1	....	....	....	....	....	15	70	13	....	....	....
	"	39	36	.66	1	1	....	....	....	1	....	10	1	80	....	5	1
	"	39	33	.50	1	....	....	....	....	1	....	....	49	49	....	....	....
	"	39	32	.50	55	10	....	....	....	10	....	....	....	5	....	....	20
	"	40	34	.25	50	....	....	....	....	....	....	....	5	....	....	....	45
	"	40	34	.50	2	1	....	....	....	....	....	....	48	48	....	....	1
	"	40	36	.75	1	....	....	....	....	1	....	50	24	24	....	....	....
	"	41	33	.25	60	....	....	....	....	5	....	....	....	20	....	....	15
	"	41	38	.50	1	....	....	....	....	....	....	80	....	18	....	....	1
	"	44	25	.75	8	....	....	....	....	1	....	....	....	90	....	....	1
	"	49	23	0	....	....	....	....	....	....	....	....	....	....	....	....	....
	7/24	40	37	.33	7	1	....	....	....	....	....	....	90	....	....	....	2
	7/29	41	35	.50	2	1	....	....	....	....	....	....	96	....	....	....	1
Tur-key Foot	7/24	32	26	.25	20	20	....	....	....	....	....	....	....	....	....	....	50
	8/7	38	29	.50	1	1	....	....	....	....	....	80	18	....	....	....	....
Franklin County	?	53	60	.50	....	....	20	3	....	2	....	....	25	....	....	....	50
	?	63	80	.80	5	....	....	....	....	....	....	10	....	....	....	60	25
	?	77	85	.50	5	....	....	....	....	5	....	....	....	....	....	20	70
	?	63	65	.15	....	....	....	10	40	45	....	....	....	....	....	....	5
	?	118	160	.80	10	....	....	3	60	....	....	....	....	....	....	....	27

TABLE III.

Fundulus diaphanus menona.

Percentage Composition of Alimentary Canal Contents.

Locality	Date	Fish Length, mm.	Intestine Length, mm.	Degree Filled	Inorganic	Blue-green algae	One-celled Green algae	Filamentous Green algae	Higher Plant Debris	Protozoa	Copepoda	Cladocera	Ostracoda	Amphipoda	Chironomid Larvae	Gastropoda	Fish Eggs	Unrecognizable Organic
TURKEY FOOT LAKE (All caught 1928)	7/10	46	30	1.00	10	....	....	8	3	5	5	10	25	....	5	....	....	29
	"	60	35	.75	5	....	....	15	5	3	....	7	20	2	20	3	....	20
	"	49	32	.15	2	....	40	....	....	....	5	15	....	5	8	....	....	25
	"	47	30	.50	10	....	....	....	5	....	25	30	....	....	....	....	....	30
	"	43	26	1.00	2	2	....	....	10	....	....	30	5	40	3	....	....	8
	"	34	17	.50	....	....	5	....	....	....	15	10	5	15	40	....	....	10
	"	46	24	.50	....	....	2	3	....	....	60	5	3	15	2	....	....	10
	"	37	22	.50	....	....	....	....	10	....	5	....	5	70	....	....	....	10
	"	34	17	.25	2	....	5	....	....	....	....	....	20	70	....	....	....	3
	"	45	24	.50	10	....	....	....	10	....	....	....	10	65	....	3	....	2
	"	48	24	.25	5	....	5	....	10	3	....	....	30	20	15	....	....	5
	"	50	28	.50	5	3	2	10	....	5	....	5	10	25	20	5	....	10
	"	37	20	.25	5	....	15	....	....	....	10	....	....	35	15	....	....	20
	"	48	25	1.00	3	....	....	10	....	....	30	....	....	40	5	....	....	12
	"	50	27	1.00	....	....	10	....	2	....	25	....	5	45	5	....	....	8
	"	47	30	1.00	....	....	3	10	....	....	....	5	2	60	10	....	....	10
	"	40	25	.25	....	5	10	....	15	....	....	10	50	....	....	....	....	10
	"	50	32	.75	3	....	5	5	3	....	....	5	10	....	15	....	35	19
	"	40	22	.50	....	....	10	....	....	5	25	50	....	....	....	....	....	10
	"	43	23	.50	....	....	7	....	....	3	30	55	....	....	....	....	....	5
	"	60	42	.25	....	....	....	10	....	5	....	5	25	30	5	....	....	20
	"	45	28	.50	....	....	....	5	....	....	7	....	10	45	15	....	....	13
	"	42	24	.75	....	....	2	3	....	....	5	....	5	20	60	2	....	3
	"	50	33	1.00	....	....	....	10	....	....	10	....	10	5	30	....	....	35
	"	53	34	0	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	"	45	26	.25	....	....	....	....	....	4	70	10	....	....	3	....	....	13
	"	57	32	.50	8	....	....	....	....	....	10	15	20	12	....	....	....	35
	"	54	28	.25	....	5	....	....	....	....	5	10	15	30	15	....	....	20
	"	50	25	.25	3	....	3	....	2	....	....	7	....	50	10	....	....	25
	"	52	30	.75	....	....	....	....	5	....	....	10	8	45	10	....	....	22
	"	51	30	1.00	3	....	5	20	7	5	....	15	10	15	10	....	....	10
	"	52	28	1.00	....	....	5	5	7	....	....	....	2	3	3	....	....	75
	"	39	15	.25	....	....	3	5	....	....	....	25	25	5	2	....	....	30
	"	53	30	1.00	....	....	3	2	7	....	3	....	5	60	....	....	....	20
	"	50	27	.75	....	....	....	5	....	....	....	10	5	25	....	....	....	55
	"	45	23	.50	....	....	....	....	....	....	15	15	15	40	....	....	....	15
	"	42	20	.15	....	....	....	....	....	....	....	10	10	....	....	....	....	80
	7/24	60	35	.75	5	....	....	5	15	....	5	2	3	....	....	15	....	50
	"	62	35	1.00	....	....	3	2	....	....	5	20	5	55	5	....	....	10
	"	55	30	.25	....	....	....	....	3	....	....	20	40	....	40	....	....	32

AN ANALYSIS OF PLANATIONAL TERMS—AN ADDITION.*

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A paper under a somewhat different title† published in 1928 has aroused comments chiefly of two types: the one questions etymology and the other desires exact definitions of the terms considered in the original report.

An introductory word on terms in general may not be amiss. A non-progressive science has little need for new terms. But in an advancing science new phenomena will come under notice; new ideas will be born; new relations will become evident; and facts already known will gradually break up into parts easily differentiated once they are recognized. An idea cannot become useful public property until it is christened; it cannot be handled, inspected, tested, talked about, circumscribed, and related until a name brings to focus the light of individuality and separate entity. However, the term of the highest value is the one that makes possible the recognition of a new phenomenon or conception for the first time, and fosters its detailed study. If a name thus calls attention to a process which would otherwise go unnoticed it has served a very useful purpose indeed.

The caution employed in regard to the introduction of a new term should be equaled only by the care exercised in its subsequent use. A few of the tests to which a term should be subjected are as follows: first, it must be a step forward in an advancing science; second, progress has discovered an idea and its corresponding phenomenon and a new term is necessary to facilitate recognition and development; and third, the term proposed should so delineate, clarify, and etch into relief the idea or fact that both will be instantly recognized in all their relationships. Utility and expressiveness should be the critical tests. The striking connotation and the clear-cut emphasis surrounding a well-chosen term may be illustrated aptly by the

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* Presented at the annual meeting of the Ohio Academy of Science, April 19, 1930.

† An analysis of erosional terms: Amer. Jour. Sci., XV, 471–483.

words "island universe" in astronomy, "barchane" in physiography, "dinosaur" in paleontology, and "electron" in physics, to mention only a few. The entrance of the word "barchane" into a discussion, for instance, arouses a definite mental picture definitive, descriptive, and causative—the term is particularly rich in suggestion. How great the difference between barchane and dune!* Names symbolical of a rich and precise nomenclature not only should aid the advancement of science but should also placard the steps of progress as they appear before us.

Let it be stated that the proposals were made not with the idea of creating an omnibus of terms to plague elementary students but with the purpose of emphasizing and perhaps predicting the trend and ramifications of physiography in relation to other phases of geology. The terms were proposed more particularly for the purpose of making it possible to direct attention upon certain processes from the standpoint either of physiography or of sedimentation, to isolate each process under a separate name so that its own peculiar characteristics stand out with utmost distinctness, and to promote an intensive analysis of the nature and method of that process.

It may be argued that a single word is sufficient to cover a number of roughly similar processes, e.g., corrasion for the destructive activities of streams, glaciers, and the wind. Yet who would wish to discard the word "plucking," a term of great utility and vividness of expression. After the same fashion abrasion by glaciers contrasts sharply with corrasion by streams in nature, method, and results. A further remark on the significance inherent in the type of term suggested will suffice, perhaps, to illustrate geologic utility. Does mariposition, for example, merit our attention? Why not use marine deposition? Strictly speaking, marine deposition means deposited in or by the sea—a rather loose definition on the whole. Mari position, on the contrary, signifies sea deposited, the agent being specifically designated. Sediments completely reworked by the sea and then subjected to mariposition receive the impress of a pure marine environment whereas those placed in the sea and scarcely touched by it receive much slighter indications of true marine surroundings. In the first case the sea is the

* W. M. Davis tells us that the Arabs have different names for dunes of different shapes. Essays, page 54.

active agent while in the second it is the passive receiver, surely a fact of significance to sedimentation.

The definitions below are appended in answer to the second comment mentioned in the initial paragraph. The scheme of terms refers exclusively to the physiographic processes and not to the surface forms. The usage of "erosion," it may be added, excludes "weathering" and restricts the word to a subject inherently active and mobile. Erosion comprehends motion; it represents part of the strikingly dynamic interlude, involving space translation, between original and derived physiographic forms.

I. PLANATION. Planation refers to the geologic activities of all the physiographic processes at work on the surface of the lithosphere tending to bring that surface to a common level.

II. EROSION. Erosion includes the acquisition of load by the physiographic agents of transportation, the actual transportation of the material, and the destruction of topographic forms and comminution of rock materials because of such transportation.

III. EOLATION. (Latin *Aeolus*, god of the winds; *-ationem*, or French *-ation*, that which is made or done by. Hence, "that which is done by the wind".) Eolation includes all the direct geologic activities of the wind, both destructive and constructive.

A. EOLIROSION. (From "eolian erosion." Latin *Aeolus*; *e* and *rodere*, to gnaw away. Hence, "wind gnawed" or "eaten away by wind".) Eolirosion includes the pick-up and transportation of materials by the wind and the geologically destructive effects accomplished because of such transportation.

1. *Eoliportation*. (Latin *Aeolus; portare*, to carry; *-ation*, the act of. Hence, "the act of wind carrying," or "carried by the wind".) Eoliportation refers to the transfer of (chiefly) rock materials on the earth's surface by the agency of the wind.

2. *Blastation*. (AS. *blaest*, a puff of wind, a blowing, plus *-ation*, the act of. Hence, "the act of blowing or rending rock".) Blastation includes the geologically destructive processes in which sand and dust particles strike rock faces or grind upon each other.

B. EOLIPOSITION. (Latin *Aeolus; ponere, positum*, to place. Hence, "wind placed".) Eoliposition refers to the

deposition of materials which have been transported by the wind; it is the process which occurs when transportation ceases or becomes ineffective.

IV. GLACIATION. (Latin *glacies*, ice, plus *-ation*. Hence, "that which is done by ice".) Glaciation includes all the geologic activities of glaciers, both destructive and constructive.

A. GLACIROSION. Glacirosion includes the pick-up and transportation of materials, produced or supplied, and the geologically destructive activities of glaciers.

1. *Glaciportation*. Glaciportation refers to the transfer of materials by the agency of glaciers.
2. *Abrasion* refers to the process by which a glacier scours and wears away a rock surface, or the fragments undergoing transportation.
3. *Plucking* refers to the process whereby a glacier lifts or tears away rock fragments or projections to which the ice has become attached.

B. GLACIPOSITION. Glaciposition refers to the deposition or rock materials which have been transported by glaciers.

V. FLUVIATION. (Latin *fluvius*, river, plus *-ation*. Hence, "that which is done by rivers".) Fluviation includes all the geologic activities of streams, both destructive and constructive.

A. FLUVIROSION. Fluvirosion designates the geologic work of pick-up, transportation, and destruction carried on by streams.

1. *Fluviportation* refers to the transfer of materials by the agency of streams.
2. *Corrasion* refers to the process whereby the channel of a stream is worn away chiefly by the impact of rock materials which themselves suffer wear during the procedure.
3. *Corrosion* is the process whereby a stream by its own solvent action, but predominantly by the help of solutes undergoing transportation, dissolves or chemically alters materials along its course of flow.

B. FLUVIPOSITION. Fluviposition refers to the deposition of rock materials which have been transported by streams.

VI. PLUVIATION. (Latin *pluvia*, rain, plus *-ation*. Hence, "that which is done by rain".) Pluviation includes all the geologic activities of rain and rainwash, both destructive and constructive.

A. PLUVIROSION. Pluvirosion refers to the geologic work of pick-up, transportation, and destruction carried on by rain and rainwash.

1. *Pluviportation* refers to the transfer of materials by the agency of rain.

B. PLUVIPOSITION. Pluviposition refers to the deposition of rock materials which have been transported by rain or rainwash.

VII. MARIATION. (Latin *mare*, sea, plus *-ation*. Hence, "that which is done by the sea".) Mariation includes all the direct geologic activities of the sea, both destructive and constructive.

A. MARIROSION. Mariosion refers to the geologic work of pick-up, transportation, and destruction carried on by the sea.

1. *Mariportation* refers to the transfer of materials by the agency of the sea.

B. MARIPOSITION. Mariposition refers to the deposition of rock materials which have been transported by the sea, chiefly waves, currents, and tides.

VIII. COLLUVIATION. (Latin *colluvies*, a mixture;* plus *-ation*. Hence, "that which is done by a mixture" or, better, "by mixing".) Colluviation includes all the geologic activities of gravity, both destructive and constructive.

A. COLLUVIROSION. Colluvirosion includes the movement of rock materials under the influence of gravity and the destructive effects accomplished.

1. *Colluviportation* refers to the movement of (chiefly) rock material under the influence of gravity.

B. COLLUVIPOSITION. Colluviposition refers to the deposition, by coming to rest, of rock materials which have undergone colluviportation.

IX. TERRAQUIATION. (Latin *terra*, earth; *aqua*, water; plus *-ation*. Hence, "that which is done by earth water".) Terraquiation includes all the geologic activities performed by ground water, both destructive and constructive.

A. TERRAQUIROSION. Terraquirosion refers to the pick-up and transportation of materials and the geologically destructive activities performed by ground water.

1. *Terraquiportation* refers to the transfer of materials by the agency of ground water.

B. TERRAQUIPOSITION. Terraquiposition refers to the deposition, or precipitation, of materials which have been transferred by ground water.

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*See G. P. Merrill: Rocks, Rock-Weathering and Soils, 1913, 307–8.

PLANATION.

DENUDATION		SEDIMENTATION	
Weathering	*Erosion*	*Deposition*	
	Eolirosion	Eoliposition	= Eolation
	Eoliportation		
	Blastation		
"	Glacirosion	Glaciposition	= Glaciation
	Glaciportation		
	Abrasion		
	Plucking		
"	Fluvirosion	Fluviposition	= Fluviation
	Fluviportation		
	Corrasion		
	Corrosion		
"	Pluvirosion	Pluviposition	= Pluviation
	Pluviportation		
	Corrasion (?)		
"	Marirosion	Mariposition	= Mariation
	Mariportation		
	Corrasion (?)		
"	Colluvirosion	Colluviposition	= Colluviation
	Colluviportation		
	Corrasion (?)		
"	Terraquirosion	Terraquiposition	= Terraquiation
	Terraquiportation		
	Solution (or corrosion)		
	Corrasion		

NOTICE

Copies of the Ohio Journal of Science, Volume 22, No. 6, are desired by the management of the Journal. The reserve supply of this issue is low and copies are wanted to meet demands for back volumes and complete sets. There is reason to believe that duplicate copies of this issue were sent to some subscribers and readers are requested to examine their files for this number. Those having copies they are willing to dispose of may communicate with the Business Manager.

THE OHIO JOURNAL OF SCIENCE

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A RECORD OF POST-GLACIAL CLIMATE IN NORTHERN OHIO.*†

PAUL B. SEARS.

OBJECT AND CHARACTER OF THE INVESTIGATION.

This paper reports the probable course of post-glacial forest succession in northern Ohio, as indicated by a study of fossil pollen deposited in the Bucyrus Bog. The object of the study has been to trace in greater detail than has yet been possible the course of climatic change since the end of the Wisconsin glaciation.

The principle employed is one which has been used in numerous European studies since 1915. It consists of a tabulation of the percentages of pollen grains of each species found in successive levels of bog deposits, and deduction of the prevailing forest composition at each level from this data. From the forest composition conclusions as to climate are drawn.

As in all stratigraphic work, certain assumptions are involved, and numerous sources of error can be pointed out. These matters have been discussed at length and tested by workers cited in a previous paper (1). For the purpose of the present paper it is perhaps sufficient to note the following points: (a) no successful impeachment of the method has appeared, although there have been several attempted (b) pragmatically, the method appears to work, and to give results which agree with those obtained otherwise (c) the method requires a clean and accurate technique, a knowledge of pollen, and an understanding of what constitutes a climatically significant fluctuation in the tabulated results.

*Contributions from the Botanical Laboratory, University of Oklahoma, NS No. 6.

†Presented at the meeting of the Ohio Academy of Science, April 18, 1930.

LOCATION AND CHARACTER OF THE BUCYRUS BOG.

This bog of about forty acres I have named from the nearest city. It was evidently overlooked by Dachknowski (2) in his survey of Ohio peat deposits. It lies two miles due east of Bucyrus, Ohio, on the North Robinson Road, fourteen miles south of the 41st parallel, and three miles east of the 83rd meridian. The glacial physiography of this region is mapped and described by Leverett (3), and the natural vegetation by the writer (4).

Located just north of the Ohio-Erie watershed, or crest-line of the state, the Bucyrus Bog is about seventeen miles southwest of the first of the ice-front lakes, now surviving as the New Haven Marsh. It is about twenty miles northwest from a contact of the Wisconsin and Illinoian glaciation, being thus fairly near the last ice edge. While not so old therefore as bogs lying nearer the edge of the ice-sheet, this bog appears to date back nearly to the beginning of post-glacial time, and in any case it gives a record of those subsequent changes which have been most significant in the development of our present floristic complex.

The bog was covered with *Vaccinium* and surrounded by groves of *Quercus* and *Carya* when the country was settled early in the last century. Not more than one-half mile south, on the other side of the watershed, were extensive areas of *Andropogon* prairie, with scattered groves of *Quercus* and *Carya*. Only two miles north, *Fagus*, *Acer* and other mesophytic hardwoods had established themselves. Nowhere in the immediate vicinity were there any conifers, except such *Larix* as might have been in this or neighboring bogs.

PREVIOUS AND RELATED WORK.

For many years assumptions as to post-glacial climate in the Great Lakes region have been the simplest possible consistent with the known facts of a gradual fluctuating recession of a huge continental ice-mass. On this basis southern species were considered to be advancing, northern retreating, and isolated bog associations have been held to be relicts of a once continuous tundra. In other words, a general moderation of climate has been assumed.

At the same time, observers have known of the existence of western plants, or even associations, far east of their present

climatic region. As instances may be cited the occurrence of *Opuntia* on the south shore of Lake Erie, along the Illinois River, and the presence of extensive *Andropogon* prairies, surrounding islands of Oak-Hickory, across much of Ohio.

Had these areas been first investigated by strictly ecological rather than floristic methods it is possible that their significance might have been missed. Gleason (5), 1909, working in Illinois, approached the problem from a floristic standpoint, however. Ascertaining that forest was increasing at the expense of prairie before white settlement, he suggested that there had been a period of widespread continental climate in post-glacial time succeeded by a recent period of increasing humidity. Following the terminology of European workers, he used the word "xerothermic" to suggest that the period of continental climate had been dry and warm.

Dachnowksi (6) from a study of the gross characters of peat strata states tentatively that Ohio peats show an irregular series of changes, due to climatic influences. After discussing evidence which deals with fluctuations during the Wisconsin glaciation, he suggests that the last advance of the ice was followed by a prolonged warm and somewhat humid climate. "This appears to have been the period of invasion and wide dispersal of forest trees from the south, and of a more northerly distribution of certain species than is now recorded for them. As to the end of the late glacial time, the climatic characteristics from the last glacial recessions to post glacial and present conditions stand as yet considerably ill defined. The evidences indicate periods during which the climatic zones shifted again somewhat. There appears to have been a return to cooler and drier climatic conditions, followed by a temperate and more humid period than exists at the present time in the same localities. The present period is probably approaching a climate of rising temperatures and (or) decreasing precipitation." He makes clear, however, that the data are insufficient for more definite conclusions, for correlation of the various deposits in this country, or for drawing parallels with other countries.

In 1926 the writer presented a reconstruction of the native vegetation of Ohio (4). On floristic and successional grounds he inferred that western as well as northern species appeared to be receding from the region, and southeastern species advancing into it. In his opinion the retreat of western forms was the

more recent, suggesting a period of continental climate in post-glacial time. The survival of bogs and other considerations led him to the conclusion (p. 229) that this arid climate had been cool rather than warm.

Auer (7) in 1927 in classifying the peats of southeastern Canada concluded that certain synchronous layers had been formed under dry conditions and expressed the belief that some correlation with the climatic sequences of Europe was possible.

Lewis and Cocke (8) in 1929 reported a pollen-analysis of the Dismal Swamp peat in Virginia. The analysis is presented and discussed in detail, and while fluctuations and disturbances are recorded, extreme caution is observed in drawing deductions as to climatic significance. The general trend of the record is one of succession from an open sedge-grass marsh to a closed mesophytic forest. At the eight and four foot levels there were disturbances which reduced the percentages of trees. The present mesophytic climax forest begins at the one foot level. It may be pointed out in passing that there is nothing inconsistent here with the assumption of a recent increase in climatic humidity in eastern North America.

Draper (9) working in this laboratory has made preliminary studies of a number of Ohio bogs. Especially noteworthy is her report of a grass-sedge-composite interval at four feet in an otherwise forest profile in the New Haven Bog. This plainly suggests a period of dryness, not far back.

COLLECTION AND SAMPLING OF MATERIAL.

Samples were taken at six inch intervals with a Davis peat sampler. Four columns were taken in different parts of the bog. The samples were wrapped individually in paper and shipped to the laboratory.

The present cover of the bog is a mixture due to secondary succession—largely *Carex*, *Poa*, *Polygonum*, *Populus*, *Salix*. There has been some attempt at drainage, and fires have occurred at several times. In the case of two of the four columns the top layer had been destroyed by fire, but the other two gave an undisturbed sequence. Three of the columns were carried down through the marl to quicksand, a distance of fourteen feet in the case of the longest.

For study, a block was cut from the center of each six-inch piece, the outside being removed to prevent possible contamination. This block was boiled in 10% KOH, centrifuged,

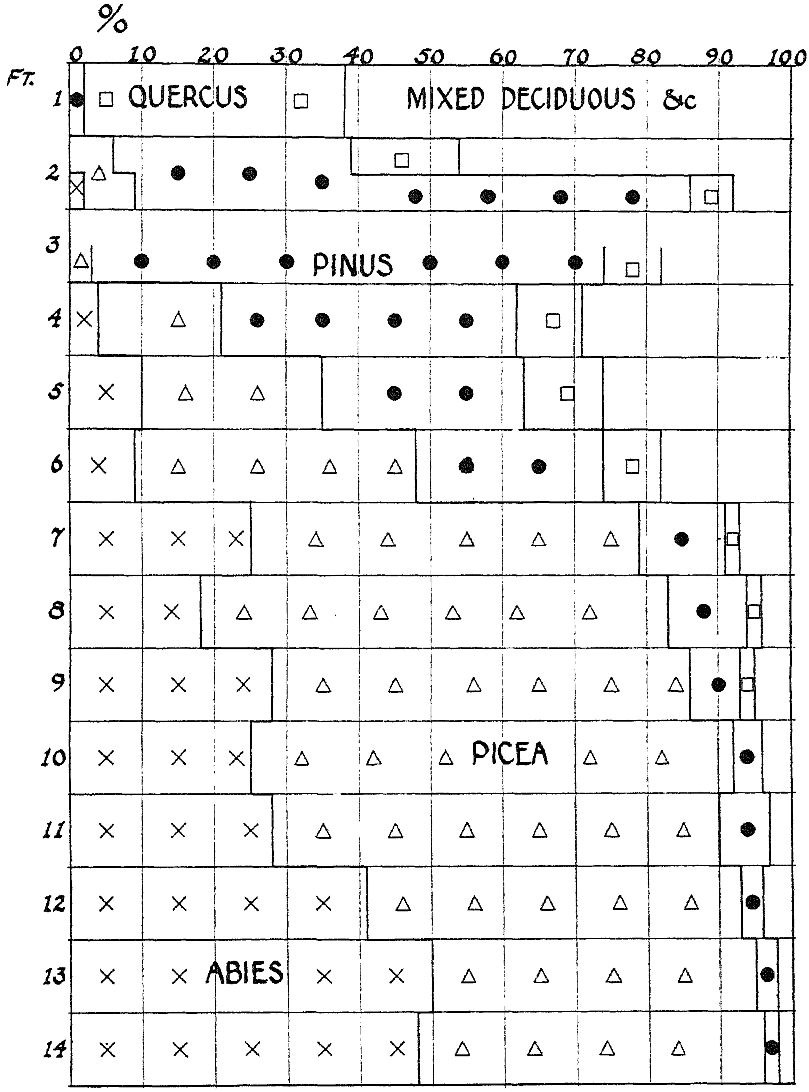

FIG. 1. POLLEN DIAGRAM OF THE BUCYRUS BOG.

At left is shown depth in feet, and across top is a percentage scale. Proportions of the four genera, *Abies*, *Picea*, *Pinus* and *Quercus* are shown for each level as they occur. Any remainder is designated as "Mixed Deciduous, etc." This includes some conifers, i. e., a little *Larix* and occasional *Tsuga*, a few herbs, e. g., *Typha*, *Graminales*, *Cyperaceæ*, but is mostly *Carya*, *Betulaceæ* and other deciduous forms. The break at 2′ 6″ represents a water pocket in the peat. In the 2′ level *Pinus strobus* replaces *P. banksiana* (and *resinosa*?). Distinct climatic equivalents are as follows: 12–14 feet—northern Labrador (cold, wet); 4–6 feet—southern Manitoba (cool, dry); 2 feet—northern Michigan (cool, moist); 1 foot—northern Ohio (increasing warmth and moisture). Generic symbols are the standard ones used by Erdtman who employs, however, graphs.

decanted, rinsed with filtered distilled water, centrifuged again and decanted. The material was then drawn up in a clean pipette, spread on a slide, dried and mounted in glycerine jelly. In strata like the lower marl and the weathered 3-foot layer where the pollen frequency was very low, the use of a centrifuge was indispensible in securing enough grains to count. At least two slides were prepared from each sample.

A key has been prepared (1) which includes most of the pollen found in this material. Wherever possible, at least 100 grains were counted from each slide. Only actual pollen was considered in figuring percentages, although spores of Sphagnum, & c. were tallied so that results could be computed if desired, as number per 100 pollen grains. It is believed that this is a more accurate procedure in dealing with cryptogamic spores than to add them in to the total. Pollen frequency (grains per sq. cm. of slide) was determined, and the presence of humified material roots and fungi noted. Valuable suggestions on method and some useful figures of American pollen will be found in the paper by Lewis and Cocke (8) as well as in the European papers cited in (1).

RESULTS.

In the accompanying tables I–IV are given the percentages of pollen at each six inch level. It will be noted that because of burning at the surface, columns 1 and 2 do not give as recent a record as columns 3 and 4 which extend to very recent times. Table VI is a condensed summary of all borings, by feet. This was obtained by connecting what, in my judgment, were corresponding levels of the four borings and grouping the results accordingly (see Table V).

The purpose of presenting the borings separately is to emphasize that pollen analysis is a clue to trends and in no sense an absolute statistical index. If the figures in each boring for *Quercus* are plotted all curves will have the same trend, but there will be no identity. Fluctuations of an order of 5-10% are to be expected. I have suggested *Quercus* because any errors in discriminating conifer pollens would not affect it. The same fact is clear, however, in comparing the conifers in those levels which were critically rechecked, and which are marked with an asterisk in the tables. But it should also be noted that while considerable fluctuation does occur at corresponding levels in different sections of the bog, *the principal*

trends are equally clear in each section. The critical points which will be shown in the consolidated graph of table V are all unmistakeable in the individual graphs of each column, if one cares to make them, as I have done in my own analysis of the data.

TABLE I.

POLLEN PERCENTAGES OF FIRST BORING.

Depth in inches‡	Abies	Picea	Pinus	Quercus	Other Genera	Pollen Grains	Pollen Frequency†
6*	05	14	49	05	27	257	60
12	01	17	43	07	32	136	167
18	00	27	47	07	19	120	81
24*	10	28	41	07	14	364	16
30*	04	33	38	08	17	342	27
36	0	22	30	10	38	92	24
42	01	32	29	05	33	110	17
48*	18	51	22	02	07	206	19
54*	23	59	13	01	04	222	33
60	05	75	09	03	08	112	37
66	10	75	07	02	06	100	37
72*	23	51	11	02	13	347	21
78*	26	71	02	00	01	360	126
84	13	84	02	0	01	123	82
90	17	76	04	0	03	118	132
96	25	70	01	0	04	106	160
102	32	61	02	0	05	122	70
108	47	49	02	0	02	129	143
114	45	53	02	0	0	131	157
120	47	51	02	0	0	118	175
126	48	47	02	0	03	121	120
132	50	41	05	01	03	109	21
						3,845	

‡Surface had been burned at this place.

*These depths were rechecked, as the numbers counted indicate. Some errors in determining coniferous pollen doubtless occurred in the original count, but the order of magnitude was small and the general trend not affected thereby.

†Grains per sq. cm. of slide. This has no standard significance merely indicating order of relative abundance in the present study.

The results summarized in table V are diagrammed in figure 1. The most striking feature of this diagram, Fig. 1 is the successive appearance and waning of *Abies*, *Picea*, and *Pinus*, all finally supplanted in the youngest layers of *Quercus* and other deciduous trees. On its face is indicated a rise in temperature from the time the bog began to the present, with a rather recent period of maximum dryness expressed in the dominance of pine at the 4-foot level, and increasing moisture

since. That much may safely be inferred from a knowledge of the ranges and ecological characters of the various genera which are most conspicuous.

In terms of present-day climates, I consider the 12-14 foot, 4-6 foot, and 2 foot levels of critical importance. In the lowest

TABLE II.

Pollen Percentages of Second Boring.

Depth in inches‡	Abies	Picea	Pinus	Quercus	Other Genera	Pollen Grains	Pollen Frequency†
6	01	11	53	08	27	165	453
12	01	24	50	05	21	111	273
18	03	08	50	10	30	358	39
24	08	16	14	23	39	139	12
30	12	50	25	04	10	52	11
36	20	55	08	06	12	51	1
42	28	62	06	03	03	404	36
48	29	66	03	01	02	341	119
54	30	52	05	05	09	60	122
60	40	52	01	01	06	109	100
66	28	60	08	02	05	414	160
72	43	51	02	01	04	481	210
78	44	53	0	0	03	116	100
84	36	56	03	0	05	129	97
90	42	56	0	·0	02	120	180
96	46	51	0	0	03	114	53
102	48	50	02	0	0	128	20
108	53	47	0	0	0	73	15
114	....	....	....	....	....	0	....
120	57	43	0	0	0	7	2
126	63	37	0	0	0	8	2
						3,380	

‡Surface had been burned at this place.

*These depths were rechecked, as the numbers counted indicate. Some errors in determining coniferous pollen doubtless occurred in the original count, but the order of magnitude was small and the general trend not affected thereby.

†Grains per sq. cm. of slide. This has no standard significance, merely indicating order of relative abundance in the present study.

levels, first mentioned, *Abies* and *Picea* both appear with a minimum of *Pinus*. This condition is found today (10) in the cold, oceanic, humid climate of northern Labrador, where *Pinus* appears not to withstand conditions as well as the other two genera. At the intermediate levels, notably the 7 foot level *Picea* and *Pinus* are most abundant, with much less *Abies* and some deciduous genera. This condition appears today in southern Manitoba, a cool, dry continental climate, where

Abies ranges west chiefly in the immediate vicinity of the larger lakes.

Until the two foot level, the species of pine appears to be *Banksiana*, with a characteristic small pollen, although *resinosa*

TABLE III.

POLLEN PERCENTAGES OF THIRD BORING.

Depth in inches	Abies	Picea	Pinus	Quercus	Other Genera	Pollen Grains	Pollen Frequency
6*	0	0	01	34	65	350	1,860
12*	0	01	02	46	52	444	640
18	0	07	19	15	60	137	252
24	....	....	....	....	....	0	....
30	....	....	....	....	....	?	....
36*	01	01	64	08	27	291	3
42	0	06	44	18	32	115	7
48	07	13	16	11	53	45	....
54*	08	29	16	09	37	107	6
60*	19	40	16	09	15	158	7
66	0	52	21	10	16	42	9
72	0	42	42	0	15	69	11
78*	23	49	15	04	09	304	....
84*	25	55	12	02	07	362	26
90	01	79	17	01	02	111	33
96	01	78	17	01	02	86	9
102	29	61	07	01	02	121	43
108	19	68	11	01	01	155	21
114	16	68	14	0	02	107	14
120	18	63	10	0	08	94	11
126	20	64	16	0	0	125	30
132	21	59	20	0	0	80	9
138	24	55	07	0	14	42	5
144	42	54	02	0	02	48	4
150	49	49	0	0	03	101	....
156	61	28	11	0	0	18	20
162	34	66	0	0	0	3	0.3
						3,515	

*These depths were rechecked, as the numbers counted indicate. Some errors in determining coniferous pollen doubtless occurred in the original count, but the order of magnitude was small and the general trend not affected thereby.

†Grains per sq. cm. of slide. This has no standard significance, merely indicating order of relative abundance in the present study.

?Through error this level was not counted.

may also be present. In any case a continuance of cool xerophytic conditions seems clear. In the two foot level, along with an abrupt increase in deciduous genera, the species of pine changes to *P. strobus*, with a larger pollen. Although this pine is rated by Hutchinson (11) as fairly low in moisture

requirements, it is commonly regarded as the most mesophytic of the northern pines, and its appearance probably indicates an increase in humidity. Today *P. strobus*, with deciduous species, is found in the fairly cool, semi-humid region of the northern Great Lakes.

In the one-foot level *Quercus*, with *Carya* and other deciduous trees represents substantially the present vegetation. A trace of pine pollen appears, but no native pine is known nearer than

TABLE IV.

POLLEN PERCENTAGES OF FOURTH BORING.

Depth in inches	Abies	Picea	Pinus	Quercus	Other Genera	Pollen Grains	Pollen Frequency†
6*	0	0	02	26	73	421	?
12	0	01	02	46	50	129	530
18	0	05	46	16	33	125	625
24*	02	07	77	06	08	355	410
30	....	....	....	....	....	0	?
36	0	0	74	10	17	111	190
42	0	07	77	06	11	124	140
48*	15	34	28	09	08	225	53
54	21	33	13	15	19	107	122
60	39	36	0	18	08	28	12
66	25	53	12	02	08	64	5
72	38	51	09	01	01	405	?
						2,094	

*These depths were rechecked, as the numbers counted indicate. Some errors in determining coniferous pollen doubtless occurred in the original count, but the order of magnitude was small and the general trend not affected thereby.

†Grains per sq. cm. of slide. This has no standard significance, merely indicating order of relative abundance in the present study.

about 35-40 miles within historical times. As compared with the preceding level the one-foot stratum indicates warming and probably further increase in humidity.

In other words the diagram indicates the following climatic sequence:

14–12 feet.	Cold, wet climate of northern Labrador.
11– 7 feet.	Gradual shift from oceanic to continental climate.
6– 4 feet.	Cool, dry climate of southern Manitoba.
3–2.5 feet.	Period of maximum dessication.
2 feet.	Abrupt increase in humidity. Cool, moist climate of Northern Great Lakes.
1 foot.	Moderation of temperature and continued increase in humidity, present climate of north-central Ohio.

TABLE V.

EQUIVALENCE OF BORINGS.

Equivalent Depth in Feet	Borings in Inches from Present Surface				Peat Character	Forest Dominants	Climate
	I	II	III	IV			
1...........	Destruction by fire and perhaps surface erosion		6 12	6 12	Brown Black	Oak, Hickory	Warmer, Humid
1–6...........			18	18	Coarse brown	Oak, Pine	Cool, moist
2–0...........			......	24	"	Pine	
2–6...........			24	30	Water pocket		
3...........			*(30) 36	36 42	Clayey "	Pine	Cool, dry
4...........	6 12	6 12	42 48	48	" "	Pine, Spruce " "	Cool, dry
5...........	18 24	18 24	54 60	54	" "	" " " "	Increasing dryness
6...........	30 36	30 36	66 72	60	" "	Spruce, Pine	
7...........	42 48	42 48	78 84	66 72	Marly "	Spruce	
8...........	54 60	54 60	90 96	....	" "	Spruce	
9...........	66 72	66 72	102 108	....	Marl....... "	Spruce	
10...........	78 84	78 84	114 120	....	" "	Spruce	
11...........	90 96	90 96	126 132	....	" "	Spruce	
12...........	102 108	102 108	138 144	....	" "	Spruce, Fir " "	Cold, humid " "
13...........	114 120	114 120	150 156	....	" "	" " " "	" " " "
14...........	126 132	126	162	....	" "	" " " "	" " " "

*Not included in count.

As confirmatory evidence of the dry conditions of the 4-2 foot level may be cited the low pollen frequency and the presence of numerous roots and much highly humified material. These plainly suggest a low water table and poor conditions for peat formation or pollen preservation.

The presence of clay in the peat deposited at the 6–3 ft. levels can, apart from the evidence of the pollen statistics, be construed with reasonable assurance as an evidence of increased dessication.

TABLE VI.

CONSOLIDATED SUMMARY BY FEET.

Feet	Abies	Picea	Pinus	Quercus	Other Genera	Total Pollen Grains Counted
1–0.........	0	0	02	36	62	1,344
1–6.........	0	6	33	15	46	262
2–0.........	02	07	77	06	08	355
2–6.........	....	....	....	....	....	0(water)
3.........	00	03	71	08	18	526
4.........	04	17	41	09	29	1,054
5.........	10	25	28	11	26	1,353
6.........	09	39	26	08	18	676
7.........	25	54	12	02	07	2,196
8.........	18	65	11	02	04	700
9.........	28	58	07	02	05	1,618
10.........	25	67	04	0	04	929
11.........	28	62	07	0	03	663
12.........	41	52	03	0	04	542
13.........	50	45	03	0	02	375
14.........	48	48	2	0	02	241
						12,834

It should also be noted that the unpublished work of Mr. George H. Lane on Iowa peats, carried out in this laboratory, confirms the above sequence in a striking way. In Iowa the period of gradual dessication caused a replacement of coniferous forest by prairie via deciduous forest. This prairie has been dominant since. But at the four foot level, corresponding to the *Pinus* period in Ohio, there is a strong increase in *Chenopodiaceæ* and *Amaranthaceæ* at the expense of grass. This suggests a xerophytic climax marked by strong evaporation and possibly alkaline or saline conditions in Iowa during the period of maxiumum dessication in Ohio. Above this level the grasses have again become dominant, additional confirmation of a recent increase in humidity.

In conclusion it appears that the climate of Ohio today is warmer than it has ever been since the Wisconsin glaciation. Since the continental maximum appears to have been cool, it seems inadvisable to use the term "xerothermic" to describe it, at least for the present.

SUMMARY.

1. Four cores were obtained in different parts of an old bog two miles east of Bucyrus, Ohio. Each one showed the same general trend of post glacial vegetation by means of the percentages of stratified pollen, counted at six inch intervals.

2. There was sufficient individual difference between cores to demonstrate that small fluctuations must not be regarded too seriously.

3. Corresponding levels in the four cores were readily located and the results grouped.

4. The sequence of vegetation appears to have been Abies-Picea, Picea-Pinus, (Pinus maximum), Pinus-Quercus, Quercus-Mixed Deciduous.

5. In terms of present local vegetation this sequence would be Northern Labrador, Southern Manitoba, Northern Michigan, Northern Ohio.

6. The sequence of climate to be inferred appears to be cold-wet Oceanic, cool-dry Continental, (Continental maximum) cool-moist Sub-continental, warmer-moister Sub-oceanic.

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THE LAWS OF MOTION UNDER CONSTANT POWER.

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The laws of motion under constant *force* form the door of introduction to the subject of Dynamics, for most elementary Physics students, and properly so. In these days of steam, electric and gasoline transportation, the laws of motion under constant *power* would seem to be only second in importance. This opinion is evidently not shared by authors of textbooks on mechanics, for in the course of several months search the writer has been unable to find a single reference to such a subject. In the meantime he has investigated the laws of this type of motion, and found that they were both surprisingly simple and remarkably easy of deduction.

The laws of motion under constant *force* may be completely described by three equations:

$$v = at \qquad s = \tfrac{1}{2}at^2 \qquad v = \sqrt{2as}$$

These equations are built on the assumption that the initial values of the variables are zero. The acceleration a is of course a constant, the value of which may be found from Newton's second law of motion, $f = ma$.

In the laws of motion under constant *power*, four variables (s, v, a and t) are involved, instead of three as in the preceding case. Six equations, each involving two of the variables, are necessary to completely describe the laws of motion. This is a consequence of the fact that the number of possible combinations of four things taken two at a time is six.

These six equations may be conveniently stated as follows:

$$a = \frac{P}{mv} \quad (1) \qquad v = \sqrt{\frac{2Pt}{m}} \quad (2) \qquad s = \sqrt{\frac{8Pt^3}{9m}} \quad (3)$$

$$a = \sqrt{\frac{P}{2mt}} \quad (4) \qquad s = \frac{mv^3}{3P} \quad (5) \qquad a = \sqrt[3]{\frac{P^2}{3m^2s}} \quad (6)$$

As before, the initial values of the variables are assumed to be zero. This is simply equivalent to saying that both distance

*Presented at the meeting of the Ohio Academy of Science, April, 1930.

and time are respectively measured from the point and instant of starting, which would, of course, be the natural thing to do. P, representing the constant power applied, must, like f in the preceding case, be measured in absolute units.

A deduction of these laws follows: By definition, $P=fv$ and $f=ma$. Combining to eliminate f, $a=\frac{P}{mv}$ (1.)

Substitute $a=\frac{dv}{dt}$ and restate equation 1 as follows: $vdv=\frac{P}{m}dt$ whence, integrating between the limits 0 to v and 0 to t respectively, $v=\sqrt{\frac{2\,Pt}{m}}$ (2.)

Substitute $v=\frac{ds}{dt}$ and restate equation 2 as follows: $ds=\sqrt{\frac{2\,Pt}{m}}\,dt$, whence, integrating between proper limits

$$s=\sqrt{\frac{8\,Pt^3}{9\,m}} \quad (3.)$$

Substitute equation 2 into equation 1 to eliminate v, whence,

$$a=\sqrt{\frac{P}{2mt}} \quad (4.)$$

Substitute equation 2 into equation 3 to eliminate t, whence,

$$s=\frac{mv^3}{3P} \quad (5.)$$

Substitute equation 5 into equation 1 to eliminate v, whence,

$$a=\sqrt[3]{\frac{P^2}{3m^2s}} \quad (6.)$$

In case it is not desired to subject the conclusions to the limitations involved in the assumption of zero initial values, the corresponding relations are readily deduced by the simple expedient of changing the values of the limits in the two integrations above.

Three of these relations are deduced without the use of calculus. Equation 1 was so derived above. In addition, one may utilize the principle of Conservation of Energy by writing

$$Pt=\tfrac{1}{2}\,m\,v^2 \quad \text{whence} \quad v=\sqrt{\frac{2\,Pt}{m}} \quad (2.)$$

Substitution of equation 2 into equation 1 gives equation 4, as before. The other three equations do not appear to readily yield to the freshman type of attack. It is a simple matter to show, however, by elementary methods, that the value of the distance in terms of the velocity, (equation 5) must lie between $\frac{m v^3}{2 P}$ and $\frac{m v^3}{4 P}$. And if it be considered allowable to conclude that the true expression is $\frac{m v^3}{3 P}$ then the remaining equations follow.

A brief glance at some numerical cases may not be entirely without interest. Calculation shows that a fifty horsepower automobile weighing two tons will travel 444 feet the first ten seconds from a standing start, will acquire a velocity of 45.4 miles per hour and will possess at the conclusion of the ten seconds an acceleration of 2.3 miles per hour per second. For five seconds the corresponding figures are 156.6, 33.1, and 3.3, and for one second, 13.9, 14.9 and 7.35.

Perhaps it is unnecessary to add the caution that in these equations power must be expressed in absolute units. In the metric system this would be ergs per second, and in the English system foot poundals per second. If the British Engineers system is used, mass will of course be expressed in "slugs" and power in foot pounds per second.

This problem assumes an entirely different aspect if, in an attempt to represent the facts more closely, we introduce terms to account for friction, air resistance and the pull of gravity in going up or down grade. It then becomes essentially a problem of motion in a resisting medium, friction and gravity representing constant forces and air resistance a force closely proportional to the square of the velocity. Introduction of these factors leads to a differential equation which anyone may be pardoned for not easily solving. A discussion of it may properly form the basis for a later report. In the meantime, we have before us the laws of motion for constant *power*, corresponding to the three classical laws for constant *force*, which have always been so much in evidence in our work in mechanics.

PRIMARY NON-DISJUNCTION IN DROSOPHILA HYDEI.*

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INTRODUCTION.

Non-disjunction of the sex chromosomes has been recorded in several species of Drosophila. Bridges ('13) studied this phenomenon first in Drosophila melanogaster. A review of his work and that of other investigators is given by Morgan, Bridges, and Sturtevant ('25), with citations of papers published up to that time. In Drosophila simulans non-disjunction has been reported by Sturtevant ('21). Weinstein ('22) recorded its occurrence in Drosophila virilis and Lancefield and Metz ('21) have studied it in Drosophila willistoni. Recently Timofeeff-Ressovsky (work unpublished) has observed non-disjunction in Drosophila funebris.

From the standpoint of comparative genetics it seemed worth while to undertake a study of this phenomenon in Drosophila hydei. Furthermore the limited investigation of the species had resulted in the finding of several sex-linked mutants which gave promise of being unusually favorable tools in a study of this kind.

Reference to Figure 1 will show the tentative map of the x-chromosome and the mutants used. In order to represent the genetic map on a larger scale a long section of the map has been omitted as indicated by the break in each chromosome shown. The x-chromosome of this species is actually a long V-shaped structure according to the cytological investigation of Metz and Moses ('23).

Notched (N) at locus 0.0 was found by Spencer ('27). It is a dominant wing mutant, causing a thickening of the wing-veins, notching of the margins of the wings, and a lethal effect in males. It is presumably lethal also in homozygous females, though in the nature of the case a homozygous female could only be produced through equational non-disjunction as there are no Notch males to pass the factor on to their daughters.

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White (w) at 3.6, and vermilion (v) at 15.1 are recessive eye color mutants found by Clausen ('23).

Bobbed (b) at 62.6 was reported by Clausen ('23), and an allelomorph (b^2), was recorded by Spencer ('27). Clausen's bobbed was used in this study. Bobbed is characterized in homozygous females by a reduction in the size of the bristles and hairs in all parts of the body, and in Clausen's allelomorph by abnormalities in the pigment bands of the abdomen in some flies. It is ordinarily sex-limited. The male, which transmits the bobbed gene in its x-chromosome is entirely normal in appearance. Bobbed mutants, parallel both in the position of their loci in the x-chromosome and in being sex-limited are known in Drosophila melanogaster and in Drosophila simulans. In the latter it is the female which is normal in appearance. In an extensive and brilliant series of researches Stern ('26a, '26b, '27, '29a, '29b) has shown through the study of non-disjunction and other chromosome aberrations involving this mutant that the sex-limited nature of the mutant in Drosophila melanogaster is due to the presence of a bobbed suppressor or normal allelomorph in the Y chromosome. His work has not only demonstrated the presence of this inhibitor in the Y, but has shown it to be limited to a certain region of the Y-chromosome.

In work on the linkage of bobbed in Drosophila hydei (Spencer '27) a male showing the bobbed character in extreme degree was recorded and interpreted as a gynandromorph. This individual was sterile. Stern ('29b) has recently referred to this individual and analysed the case not as a gynandromorph, but as being due to non-disjunction in the male parent resulting in a sperm carrying neither X nor Y-chromosome, which on fertilizing an X-bearing egg produced this male with X composition and sterile through lack of the Y-chromosome.

PROCEDURE AND RESULTS.

As shown in Figure 1 females heterozygous for Notch, homozygous for white and bobbed, and carrying the wild-type allelomorphs at the vermilion loci were mated to males carrying the wild-type allelomorphs for Notch and white at their respective loci, the vermilion and bobbed genes in their X-chromosome, and presumably carrying the bobbed suppressor in the Y-chromosome. From such a cross three classes of offspring would be expected to occur in about equal numbers:

white-eyed, normal-winged, phenotypically normal-bristled males; mahogany-eyed (wild-type), Notch-winged, bobbed-bristled females; mahogany-eyed, normal-winged, bobbed-bristled females. Reference to Figure 1 will make this clear. The fourth genotypic class, the white Notch males do not appear among the phenotypes, due to the lethal action of Notch. Table 1 gives the actual results of counts of the offspring from 146 cultures of the above cross.

TABLE I.

THE OFFSPRING FROM 146 SINGLE MATING CULTURES OF NOTCH, WHITE, BOBBED FEMALES TO VERMILION, GENOTYPICALLY BOBBED MALES.

Phenotypic Classes	Number of Flies
White-eye, normal-wing, normal-bristle males................	4,735
Mahogany-eye, normal-wing, bobbed-bristle females..........	5,067
Mahogany-eye, Notch-wing, bobbed-bristle females...........	4,482
White-eye, Notch-wing, normal-bristle females..............	7
Vermilion-eye, normal-wing, extreme bobbed males..........	3
White-eye, normal-wing, extreme bobbed male...............	1
White-eye, normal-wing, normal-bristle female...............	1
Vermilion-eye, normal-wing, bobbed-bristle female...........	1
Total Flies..	14,297

EXPLANATION AND DISCUSSION.

In Table 1 of the total of 14,297 offspring all but 13 belong to the classes expected. The three expected classes occur in approximately a 1 : 1 : 1 ratio. As is usually the case in counts involving Notch this class is somewhat lower than the others, due to a lessened viability of the Notch flies. It should be stated that the bobbed character is not always easy to identify in females and there is some tendency to overlapping of the wild-type. However, in most of the individuals it could be distinguished and all females of the mahogany Notch and mahogany normal-winged classes have been classed as penotypically bobbed.

The seven white-eyed, Notch-winged, normal-bristled females and the three vermilion-eyed, normal-winged, extreme bobbed males are due to non-disjunction of the X-chromosomes of the female parent. This is made clear by reference to Figure 2. In non-disjunction of the reductional type the two X-chromosomes of the primary oocyte may either go into the second-

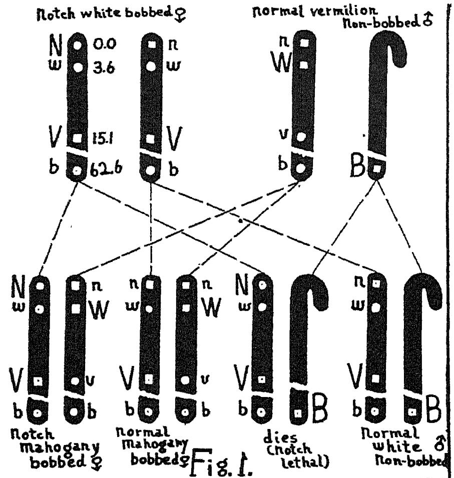

Fig. 1.

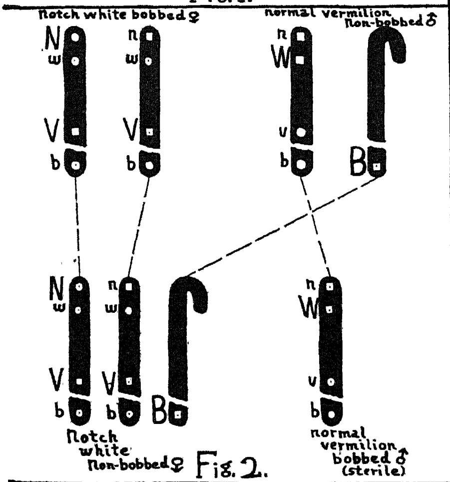

Fig. 2.

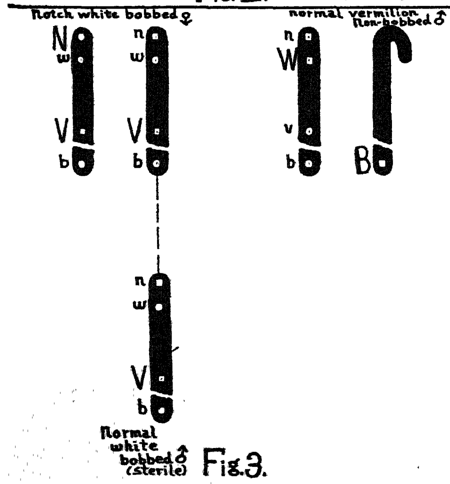

Fig. 3.

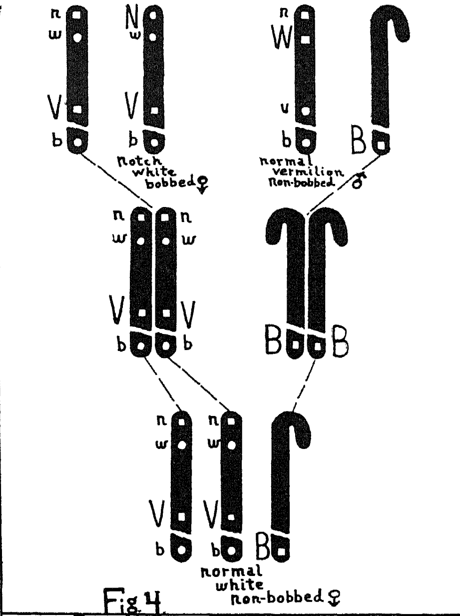

Fig. 4

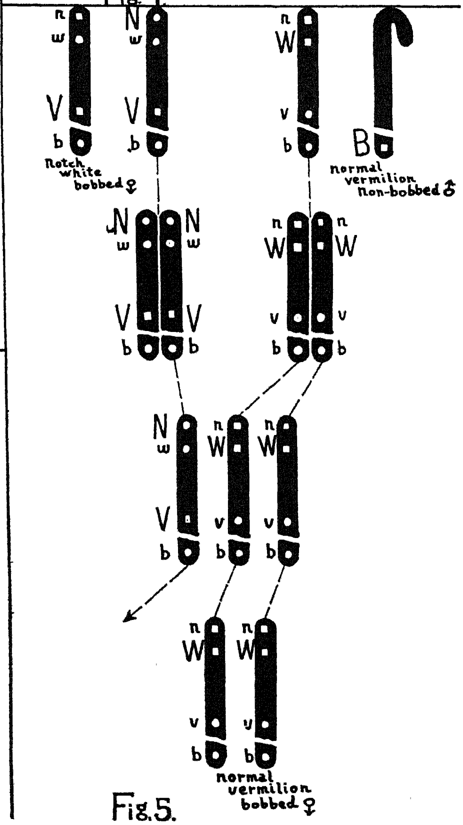

Fig. 5.

ary oocyte together or they may be expelled together into the first polar body, leaving the secondary oocyte without any X-chromosome. When an egg containing the two X-chromosomes of the mother is fertilized by a Y-bearing sperm a female is formed, with an XXY constitution as indicated by the offspring to the left in Figure 2. These females are Notch and white-eyed like their mothers, but as they each carry a Y-chromosome they are not bobbed like their fathers. When an egg without either X is fertilized by an X-bearing sperm a male is produced, XO in composition, vermilion-eyed and normal-winged like the father, but showing the bobbed character as the Y-chromosome with its bobbed suppressor is not present. The genotype of such an individual is shown to the right in Figure 2. In Drosophila melanogaster it has been shown that XO males are always sterile. The three vermilion, extreme bobbed males were mated each to several sisters but all proved to be sterile. Thus the XO composition of these males is shown by their eye-color, their possession of the bobbed character in extreme and unmistakable form, and their sterility.

The explanation of the one white-eyed, extreme bobbed male is to be found in Figure 3. In this case non-disjunction in the male parent resulted in the formation of a sperm with neither X nor Y-chromosome present. When this sperm fertilized an egg bearing a single X with the white, normal-

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EXPLANATION OF FIGURES.

Fig. 1. The sex-chromosome composition of a Notch, white, bobbed female and a normal-winged, vermilion, phenotypically non-bobbed male and of the classes of offspring to be expected from them when normal disjunction of the sex-chromosomes occurs in both parents.

Fig. 2. The two classes of offspring resulting from primary non-disjunction of the reductional type. The XXY female produced by fertilization of an XX egg by a Y sperm and the XO sterile male coming from the fertilization of an egg bearing no X by a sperm carrying an X.

Fig. 3. A sterile male produced by primary non-disjunction of the reductional type in the male parent. An X-bearing egg fertilized by a sperm carrying neither X nor Y and due to reductional non-disjunction in the male parent.

Fig. 4. An XXY female due to primary non-disjunction of the equational type in the female parent.

Fig. 5. A patroclinous female receiving her two X chromosomes from the male parent as a result of equational non-disjunction in this parent followed by the elimination of the maternal X as shown by the arrow.

Note.—The X chromosome is represented as a straight rod, the Y chromosome as a hooked rod. The break in the chromosome represents a long section of the genetic map left out. The squares represent the normal or wild-type factors or genes and the circles the mutant factors.

winged and bobbed genes in it a male of the above phenotype was produced. This XO male was sterile. The use of the bobbed mutant makes it possible to detect non-disjunction in the male. If the bobbed character were not being followed non-disjunction could occur in the male without detection, as individuals from non-disjunction sperm would not differ phenotypically from those which had come from ordinary sperm. Stern ('27, '29b) has recorded non-disjunction in the male in bobbed stocks of Drosophila melanogaster.

The one white-eye, normal-winged, normal-bristled female is accounted for by equational non-disjunction of the not-Notched chromosome of the female parent as shown in Figure 4. Equational non-disjunction, while not as common as that of the reductional type, has been repeatedly recorded in Drosophila melanogaster. In the present instance the heterozygous Notched condition of the female parent makes it certain that the non-disjunction was of the equational type. A possible alternative explanation of this individual would be that of gynandromorphism. The not bobbed condition might then be due to normal overlapping of the bobbed character. The female might have received one X-chromosome from the father and one from the mother. The paternal X might have been eliminated from an early cleavage cell, from which all eye tissue developed. This would give a gynandromorph, female posteriorly and male and with white eyes anteriorly. Such a gynandromorph would, however, have produced sons half of which would have been white and the other half vermilion. This female on being bred produced only white-eyed sons, showing that she was homozygous for white. This fact proved that both her X-chromosomes were derived from her mother. They must have come from the not-Notched X through non-disjunction at the equation division, as the fly was not Notched.

That none of the seven Notched white females recorded above were due to equational non-disjunction of the Notch bearing chromosome was shown by breeding tests. Had any of the above flies been homozygous for Notched through equational non-disjunction they should have given only Notched daughters and no sons at all. As none of them gave this result on breeding it seems clear that each of the seven was due to reductional non-disjunction. This is in accord with the implication that homozygous Notched females would be lethal as are Notched males.

The patroclinous vermilion-eyed, normal-winged, bobbed female presents some difficulties. In Figure 5 a formal explanation of how such an individual might have occurred is given. It must be supposed that equational non-disjunction has occurred in the male, resulting in a sperm with two paternal X-chromosomes. This sperm fertilizes either an egg which through non-disjunction lacks an X or an X-bearing egg. In the latter case there is elimination of the maternal X soon after fertilization resulting in a female homozygous for the sex-linked factors of her father. The simultaneous occurrence of non-disjunction in male and female gametes seems an event so extremely rare that we may disregard it in favor of the alternative of non-disjunction in the male followed by somatic elimination of one of the three X-chromosomes (in this case the one maternal X) from the zygote. While there is little evidence on the point it would not seem unlikely that the presence of an extra X-chromosome in the zygote might favor the loss of an X during an early cleavage stage. Mrs. L. V. Morgan ('22) has shown that the female from which the double yellow stock with attached X-chromosomes has been derived was a mosaic due to somatic elimination of the maternal X from a fly which had arisen from an equational non-disjunction sperm fertilizing an X-bearing egg. She cites two additional cases (L. V. Morgan '29) in Drosophila melanogaster in which this sequence of events has occurred. The alternative explanation of gynandromorphism in our present case was shown to be invalid by breeding tests. All sons from this female were vermilion showing that the fly was homozygous vermilion.

The data presented here give about one individual in 1100 from primary non-disjunction of the sex chromosomes. This is a somewhat higher percentage than that given for Drosophila melanogaster by Morgan, Bridges and Sturtevant ('25). However, the data in our present study are insufficient to give an accurate idea of the relative frequency in the two species. Mrs. Morgan ('29) has suggested that Notched and bobbed may both tend to increase non-disjunction. Whether this be true or not they do favor its study and analysis. It is significant to find that primary non-disjunction in this species gives rise to essentially the same phenomena, especially in the case of bobbed, as are found in Drosophila melanogaster.

Secondary non-disjunction is at present being studied in this species and will be reported on at a later date. It may be

said that the secondary exceptions are apparently of a much lower frequency than in other species studied.

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NEW REPORT ON NEW BRUNSWICK.

The Canadian Department of the Interior has just issued a beautifully printed and illustrated report on New Brunswick of 166 pages, with 33 photographs, 10 sketch maps and a general map in color. "The potentialities of this maritime province have undoubtedly been overlooked during the period of the agricultural development of Western Canada and the industrial growth of Ontario and Quebec, for it is only recently that its water-powers and forest wealth have been utilized in large-scale pulp and paper enterprise. Progress in this direction has indeed been remarkable. Last year the largest power site in the Maritimes was developed at Grand Falls, with an installation of 60,000 horse-power and transmission line of 104 miles to Chaleur Bay; 5,500 horse-power was added to the 9,000 horse-power already developed on the Nipisiguit; the capacity of the plants at Edmundston and Bathurst were enlarged; while a newsprint mill with an initial daily capacity of 250 tons came into operation in March, 1930; and a bleached sulphite mill at Athol has lately been completed.

"A similar awakening is in evidence in regard to the fertile and cheap agricultural lands, minerals and fisheries, and the many recreational attractions of the province, all of which resources and the development opportunities they present are dealt with in this governmental publication, which can be obtained from the Director, Natural Resources Intelligence Service, Department of the Interior, Ottawa."

INTERNAL ANATOMY OF EURYURUS ERYTHROPYGUS (BRANDT). (DIPLOPODA).*†

HUGH H. MILEY.

INTRODUCTION.

In a previous paper the writer (1927) reported the results of observations upon the development of the male gonopods, distribution and life history studies of *Euryurus erythropygus* (Brandt), a Polydesmid millipede, which lives on decaying wood.

A review of the anatomical literature on Diplopods revealed no information concerning the internal anatomy and physiology of *Euryurus*. Anatomical studies available were mainly on European forms, mostly of Germany, and with relatively little included on the *Polydesmidæ*. The literature on investigations concerning the digestion and embryology of the alimentary tracts of the Myriapoda, as well as some other studies, is rather meager. There exists no connected description of the Diplopods or Chilopods. The anatomical studies of Attems (1926), Randow (1924), Verhoeff (1910–1915), and (1926), in Bronn's "Tier-Reich," Effenberger (1909), Wernitzsch (1910) and Rossi (1901), (1902) are the most extensive and important for Diplopods. The best bibliographies were found in the references by Latzel (1884), Attems (1926) and in Bronn's "Tier-Reich" (1926).

The whole subject of arthropod histology during moulting and metamorphosis is rather obscure and there are often as many interpretations as there are investigators.

This paper deals with the internal anatomy of *Euryurus*, the histology of the mid-intestine during ecdysis and feeding condition, fauna found in the intestinal canal and especially with the body, leg and mandible musculature and the gross and histological anatomy of the digestive tract. A comparison with the anatomy of other *Polydesmidæ* and *Julidæ*, already studied, showed differences and similarities.

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Leidy (1851) first called attention to the extensive floral and faunal association within the ventriculus, the large intestine and rectum of *Spirobolus marginatus*, a millipede, which, like *Euryurus*, lives on decaying wood. His description of the alimentary tract will be included in the discussion of the tract of *Euryurus*.

In all specimens of *Euryurus* in which the intestinal tract was examined flora and fauna were found. The fauna found are as follows: Gregarines in the fore-intestine (genus and species not identified); *Nyctotherus velox*, a protozoan, in the hind-intestine and rectum.

The nematodes *Rhigonema infectum*, *Thelastoma attenuatum*, identified by N. A. Cobb, were found in the posterior part of the mid-intestine and the anterior portion of the hind-intestine. The malpighian tubules are located on a portion of a constricted area (Plate III, Fig. 4). As many as fifteen nematodes were found in a small area just preceding the constriction and as many as twenty-six in a small area following it.

Mites as ectoparasites were observed in a few cases.

A few investigators have studied the physiological relationship of many insects to organisms, but the writer has found nothing of a similar work on the Myriapoda.

Material and Technique.

The animals used were collected near Oxford, Ohio, although a few were found around the vicinity of Columbus and Lancaster, Ohio. Attention is called to a wider distribution of this organism than previously reported by the writer (1927). Many adults and especially a large number of moulting and non-moulting larvæ, of all stages, were found in their natural surroundings by the writer at Oxford, the latter part of August (1927). The millipedes are easily kept in the laboratory and breed in the somewhat artificial environment described by the writer (1927). An abundance of material was available for study, including adults and the seven larval stages.

Many difficulties have been encountered in these studies, both in gross dissections and histological technique. The feeding animals, especially adults and later larval stages, besides being small and flat have an extremely thick, hard and brittle chitinous exoskeleton and the underlying extremely delicate tissues adhere closely to the chitin. *Spirobolus margi-*

natus, a much larger, cylindrical millipede, is much easier to work with because of its size, shape and flexible chitinous body wall.

The internal anatomy described has been determined by careful gross dissections of feeding adults, moulting and non-moulting larvæ, using binocular microscope, and by serial transverse and longitudinal sections of entire animals. Serial longitudinal sections of all stages were prepared.

Material fixed in Carl's or Henning's or Gilson's fluids gave good results. Delafield's hematoxylin and eosin were used for ordinary studies and Heidenhain's iron hematoxylin for cytological work, with sections cut from 3 to 5 microns in thickness. Sudan III was used in testing for fat. Euparol, used instead of balsam, was also found valuable.

Photomicrographs of histological details have been taken and drawings made using a micro-projector drawing apparatus in vertical position.

INTERNAL ANATOMY.

The Alimentary Canal.

Effenberger (1907), (1909), Verhoeff (1914), (1910-1915), Attems (1926) have made rather extensive observations on European *Polydesmidæ*. Effenberger (1909) compared *Polydesmus* with *Julus* studied by Krug (1906). The outstanding works on *Julidæ* are by Plateau (1876), Voges (1878), Visart (1894), Krug (1906), Verhoeff (1910-1915), Randow (1924). Randow (1924) made the most extensive comparisons regarding the morphology and physiology of the intestinal canals of *Julidæ*.

Leidy (1851) gives a short description of the alimentary tract using a slightly different terminology from that generally used at present. Considering, as with the insects, that the attachment of the Malpighian tubules is a landmark in marking off the hind-intestine from the mid-intestine, the proventriculus as used by Leidy consists of the fore-intestine and the mid-intestine, which includes the ventriculus or true stomach. In *Polydesmidæ* and *Julidæ* the hind-intestine commences with a ring fold shown as (RF) in Plate III, Figs. 4, 4-C. This ring fold is slightly anterior to the attachment of the Malpighian tubules.

The ventriculus according to Leidy is a part of the hind-intestine, since it is set off from the mid-intestine by the attachment of the Malpighian tubules and is lined with a chitinous intima. Leidy called the Malpighian tubules biliary tubes and the hind-intestine the large intestine.

The later writers on *Polydesmidæ* and *Julidæ* divided the tracts into three main divisions, namely, fore-, mid-, and hind-intestine.

The intestine of *Euryurus* shows some similarities with and some differences from similar studies on European *Polydesmidæ* and *Julidæ*.

The Gross Anatomy of the Adult Canal of *Euryurus*.

The alimentary canal of the adult *Euryurus* shows considerable specialization in form and structure. It extends in almost a straight line from mouth to anus and is very large and capacious in relation to the size of the animal, in accordance with the nature of the food. There is a general rule that in herbivorous insects the alimentary tract is longer or more capacious than in carnivorous insects. In the local Myriapoda, the digestive tract has, for the most part, a greater circumference in the Diplopods. Three chief divisions of the tract of *Euryurus* are readily recognized, the fore-intestine (stomodeum), the mid-intestine (mesenteron or ventriculus), and the hind-intestine (proctodeum). The general form of the external gross anatomy is shown in Plate III, Fig. 4, and of the internal gross Anatomy in Plate III, Fig. 4. The natural lengths of three portions of the photographed alimentary tract were as follows: fore-intestine = 5 mm.; mid-intestine to Malpighian tubules = 13 mm.; Malpighian tubules to anus = 16 mm.

The oseophagus is a comparatively short slender tube, lined with a chitinous intima, extending to about the fourth trunk segment. Here it enlarges and connects with the mid-intestine. Internally at this junction there is a projecting valve which is formed by a padded girdle composed of six cushions or elevations each of which has a ridge in the middle extending into a point. These points (P) are quite long and bend outward into the lumen. (Plate I, Fig. 3 and 4-C). There is a ring furrow in front of the girdle. As many as twelve long rods, attached anteriorly in the oesophagus, have been counted projecting into the mid-intestine. Two, curving to a common attachment in the oesophagus, were noticed in some specimens.

The mid-intestine is a rather long, capacious, straight tube and is ochreous yellow in color. It is almost uniform throughout in size and usually smooth, although some irregular folds were noticed. The intestine commences to decrease in diameter a short distance anterior to the entrance of the Malpighian tubules. Where this narrowing begins there is a noticeable internal thickening encircling the intestine. A gross internal examination reveals a ring fold or valve and a ring furrow. (RF) (Plate III, Fig. 4-C). This marks the commencement of hind-intestine and the Malpighian tubules enter the intestine a short distance posterior to the ring fold. For insects the attachment of the Malpighian tubules is considered as the landmark in setting off the hind-intestine from the mid-intestine. Verhoeff (1910-1915) states that the ring fold is absent in European *Polydesmidæ*. The mid-intestine and its digestive epithelium terminate abruptly, being followed immediately by hind-intestinal epithelium. Sometimes there is a thickening of the muscle layers at this junction and it is spoken of as the pyloric valve in insects. In *Euryurus* there is considerable thickening of muscle layers posterior to the ring fold and which continues a short distance posteriorly. This, by Attems (1926), was called a closure valve (Verschlussklappe) in *Julidæ*. This portion Leidy called the ventriculus and it is short, cyclindrical and much narrower and stronger than the mid-intestine. Upon its exterior surface it is smooth.

Internally, as with the oesophagus, a series of longitudinal folds were noticed in the chitinous intima, and long rods, resembling those found in the oesophagus, were observed in this region.

Verhoeff (1910-1915) has discussed the hind-intestine of certain European *Polydesmidæ*, comparing them with the *Julidæ*. Krug (1906) divided the hind-intestine of *Julidæ* into three sections. Verhoeff divided the hind-intestine of *Julidæ* into five sections, namely, a urine chamber, fold chamber, wrinkled chamber, pre-anal constriction and rectum. The long main chamber of the hind-intestine of *Polydesmidæ*, he compared to the fold chamber and wrinkled chamber of *Julidæ*. Randow (1924) found five sections but he called the first "*Verschlussklappe*" or closure valve.

In *Euryurus* the hind-intestine is narrow for a short distance posterior to where the Malpighian tubules enter it. It widens rather abruptly and continues about the same size to the pre-anal constriction, and again widens into the rectum. The hind-intestine is stronger than the mid-intestine and externally presents some irregularities such as indentations and slight folds, and is dark brown in color, for the most part. Internally a urine chamber, a fold chamber, a pre-anal constriction and a rectum are present. However, these sections vary in many respects from those of European *Polydesmidæ* and *Julidæ* observed by others. At the ring fold there are numerous longitudinal elevations and depressions. Larger longitudinal folds are seen in the narrow region and these continue to the fold chamber which in *Euryurus* is characterized by numerous small, dark brown papilla-like structures which have not been described in the literature reviewed. The pre-anal constriction presents a chitnous intima with longitudinal folds.

The writer (1927) named the mouth parts and described some aspects of the external anatomy of *Euryurus*.

The Histological Structure of the Fore-Intestine.

Oesophagus.—A pharynx is not referred to in the literature reviewed but Effenberger (1909), Verhoeff (1910-1915), Attems (1926) describe the fore-intestine as being hexagonal in shape behind the mouth opening. This is true for *Euryurus* but further posteriorly a cross section presents a different picture.

The fore-intestine for its entire length has a heavy chitinous lining continuous with that of the body wall. This chitinous cuticula is of uniform thickness but the epithelium and muscles vary some in the different regions. Near the mouth opening the epithelium consists of a definite, thin layer of small irregular cells. Further posterior the epithelium gradually thickens to the region characterized by a series of usually six longitudinal folds (Plate I, Fig. 1 and Plate II, Fig. 1).

The primary intima is well developed. The secondary intima underneath is almost transparent.

The epithelium consists of irregular elongate cells, whose nuclei located near the bases contain deep staining chromatin material. A basement membrane is present. (Plate I, Fig. 2.)

The longitudinal muscles start near the mouth and are most numerous at those points where the epithelium invaginates. They do not

all run directly longitudinally, but some intervene, so that cross-sections of this region show some of them running in an oblique fashion. All sections prepared show that the space between the epithelium and the circular muscle layer is not completely filled by these longitudinal muscles. Tracheoles were present, scattered among the longitudinal muscle fibers and what Effenberger (1909) and Krug (1906) called a homogeneous connective tissue. No connective tissue cells were observed in *Euryurus* as Krug (1906) reports for *Julus*.

The circular muscles form a layer outside the longitudinal muscles. This layer varies somewhat in thickness and completely surrounds the tract. Striations are easily observed here as well as in muscle of other portions of the tract except in the mid-intestine. Visart (1895) concluded from his studies on other forms that all the muscle in the intestine is striated. Randow (1924) seems to have the same opinion in regard to Julidæ.

Oesophageal Valve.—The fold of tissue composing this valve lies in the transition from the fore-intestine to the mid-intestine. (Plate I, Fig. 3). The gross appearance has been previously described by the writer. Effenberger (1909) merely mentions the presence of a valve in *Polydesmus.* Intima, epithelium, basement membrane, longitudinal and circular muscle fibers are present. The main structure of the fold is similar to that of the oesophagus.

The intima ends at (A) on the posterior surface of the fold which marks the limits of the fore-intestine.

The epithelium of the anterior face of the oesophageal valve continues much the same as in the oesophagus until just before reaching the tip of the fold. Here the cells gradually elongate until the end of the fore-intestine is reached. The epithelial cells of the mid-intestine are cuboidal at the annulus where they commence. A short distance back they are higher and rod-shaped. The basement membrane is continuous from the fore-intestine to the mid-intestine.

The longitudinal muscles of the fore-intestine end near the base of the fold. On the posterior surface of the fold the inner longitudinal muscles of the mid-intestine commence. They are fewer in number and smaller than those of the fore-intestine.

The circular muscles of the fore-intestine end near the annulus on the posterior surface of the oesophageal valve. The circular muscles of the mid-intestine appear soon after the inner and outer longitudinal muscles of the mid-intestine begin. They form a continuous layer.

The Mid-Intestine.

The mid-intestine or ventriculus is an elongated tube and is almost of uniform size. (Plate I, Figs. 4, 5). Its lumen is considerably larger than that of the oesophagus and is without folds. The histology of this portion of feeding animals varies in some respects from that of moulting forms so will be described separately.

A. Feeding Condition.

Cross sections of tracts of feeding animals showed the condition indicated in Plate I, Figs. 4, 5 and Plate II, Fig. 2. Towards the

lumen the epithelial cells are covered by a rod-like fringe. (CSB). This extends from behind the oesophageal valve at the anterior end of the mid-intestine to within the hind-intestine. Many times one observes a separation of the fringe but in many places it remains in position. The rods do not stain with eosin.

A membrane analogous to the peritrophic membrane of insects is present in *Euryurus* but the cuticula is distinct and separate. In the insects the usual explanation given is that this process of formation continues indefinitely and the peritrophic membrane shrinks around the food in the lumen of the intestine, while new membranes are repeatedly being formed by the discharging epithelial cells.

The epithelium is composed of a single layer of small cylindrical cells which appear like a fringe of very small rather uniform rods located on a tunica propria or basement membrane.

Some of the cells are larger towards the lumen. The growing cells push themselves between the old cells. Mucous cells as found by Balbiani (1890) in *Cryptops* were not observed in *Euryurus* nor did Randow (1924) find them in *Julidæ*.

Secretion is holocrine, that is, the entire cell contents are discharged into the lumen of the gut.

The cells, in *Euryurus* have comparatively large nuclei, nucleoli, chromatin lumps and contain much granulated secretion. The cell membranes in thin sections are usually very distinct. On the distal borders of the cells a thin homogeneous, non-alveolar edge is found under the rod-like fringe.

The tunica propria or basement membrane is a smooth or slightly waved lamella. It cannot be easily differentiated from the layers of circular muscle which follow.

Outside the two circular muscle layers is found a layer of cells which Plateau (1876) and Visart (1895) called adipose tissue in the forms they studied. Rossi (1902) and Leger and Duboscq (1904) are against this opinion. Krug (1906) called it "Drusenschicht" or glandular layer and Randow (1924) prefers the more general names "Hullschicht" or "Leberschicht" designated by Verhoeff (1910-1915) as the function of this layer is in many respects that of a liver. Fixing with osmic acid in a number of cases has not shown it to be a fat network. Sudan III proves the presence of fat in some cases.

This, in *Euryurus*, is a single layer (H) which is found over the entire mid-intestine. The cells are of various sizes. Its structure is compact just as Krug (1906) and Randow (1924) observed in *Julidæ* but Verhoeff (1910-1915) described it as being loose. The nuclei are spherical and show chromatin lumps in connection with the nuclear membrane and nucleoli. Frequently open spaces were observed where presumably xylol had dissolved the fat.

Yellow granules of various shapes are very characteristic in the covering layer.

The writer observed an increase of granules after specimens of *Euryurus* were starved for some weeks. Possibly the granules were excretory material but tests for uric acid and guanin were negative as were tests for albumen and stored iron.

No such layer, in a similar position, is found in insects.

In *Euryurus*, what is thought to be internal small longitudinal muscles surrounded by clear spaces are present at regular intervals in the portion of the network near the layer of circular muscle.

External groups of longitudinal muscle were observed outside and attached to the network.

The intestine of *Euryurus* is surrounded by numerous fine tracheoles. The tracheoles frequently pierce the network as is indicated by small, spherical bodies with clear spaces observed in sections.

B. Moulting Condition.

The condition of the mid-intestine of a specimen in the seventh larval stage which had just shed its exoskeleton is shown in Plate II, Fig. 3. This condition has been observed only in moulting or just moulted specimens of all seven stages of *Euryurus* sectioned. Gross dissections and microscopic sections of many specimens have disclosed no such condition in the tracts of feeding animals. The bodies labelled (DC) have been grossly dissected from moulting specimens. The bodies apparently not containing nuclei but concentric optical rings were not green in color but in view of the possibility that they might be algæ or fungi, cultures were tried, using plain agar agar and nutrient agar media and filtered lake water to which had been added decaying wood and heated to boiling. After many attempts these bodies were not successfully cultured. That some of the bodies are slightly phagocytic has been shown by experiments, using India ink and carmine, as they ingested small droplets of the ink or carmine. That the condition is not seasonal has been shown by sections of animals made during summer, fall, winter and spring.

The preceding observations seem to indicate that the condition is connected with the process of moulting and its associated phenomena. It is apparent that if this be true the process is very intricate. At any rate many questions concerning it are yet unsolved.

The bodies (DC) may be digestive cells given off from the old epithelium of the mid-intestine. It appears also that there has been a regeneration of the entire mid-intestine epithelium and that an old epithelial ring (AE) lies inside the outer tube. The cells have been observed multiplying amitotically in the inner ring.

In serial cross sections a pocket begins ventrally and anteriorly. (Plate I, Fig. 15-A). This is outside the circle of a tomodeal epithelium. Followed posteriorly, the pocket widens, and soon the stomodeal wall is interrupted ventrally (Plate I, Fig. 15-B). Continued posteriorly, the discontinuous stomodeal ring shrinks dorsally, and a crescent of other epithelium expands dorsally, until finally the former disappears and the entire tube is composed of the epithelium continued backward from the outer wall of the original pocket. (Plate I, Fig. 15-C).

This can only mean that the pocket is the anterior end of the ventricular lumen outside the lower lip of a short preventricular fold between stomodeum and mesentoron, or ventriculus. The same structure occurs in insects; the preventricular fold may be a mere rim at the anterior orifice of the stomach, or a long funnel-like tube. In

Euryurus it is very short, and the opening slopes from above forward and downward.

Verhoeff (1910-1915) in his eighth number of "Die Diplopoden Deutschlands" described his observations and those of vom Rath (1890) briefly in regard to the relations of the intestinal tract to moulting and above all to the characteristic phenomena which he designated as "leucocyte flood." His statements are mainly relative to *Iulidæ*, while *Polydesmus* and *Craspedosoma* are only briefly treated. Most of his material regarding *Polydesmus* is in a special article (1914) devoted to the transformation of the mid-intestine in *Polydesmus* during the moulting periods. A series of *Polydesmus monticolus vallicolus* Verh. larvæ in stages of moulting were observed and differences from conditions in *Iulidæ* were recorded and a few physiological factors considered.

Verhoeff stated that his theories concerning mid-intestinal histolysis show many loop-holes, which, he commented, is not surprising as it has never been observed before and is a very intricate process. It is true that many questions are yet unsolved. Verhoeff claims that the spheres are not digestive droplets because they are much larger and often nucleated and have the same appearance as leucocytes.

Randow (1924) in his studies upon espithelial regeneration did not include observations during moulting. In *Julus* he states that the renewal of epithelium takes place through "Blastemzellen" found over the entire mid-intestine as previously mentioned.

Randow and Verhoeff are the only workers who have made observations upon the epithelial regeneration in *Julidæ*. Randow objects to Verhoeff calling the epithelial cells leucocytes, a name which he thinks should be reserved for bodies in blood and body cavity fluids. Otherwise he is in agreement with Verhoeff's observations of regeneration during the non-moulting condition.

Hundreds of sections through the mid-intestine of just moulted specimens of *Euryurus* showed the condition as shown in Plate II, Fig. 3. There were two layers of epithelial cells and in between large numbers of spherical bodies of various sizes and some in clumps. They show concentric optical rings but apparently no nuclei. If present nuclei are not clearly defined. The cells of the outer epithelium are regular and key-like in arrangement. Cylindrical cells lie next to and near this layer. The epithelial layer lying in the lumen is in a stage of degeneration and has lost its cellular nature. Verhoeff called this the yellow layer. The dissolution of this layer and cells forming by amitosis have been observed. Spherical cells have always been observed in and outside the old layer. They are smallest inside where dividing and gradually are larger outside. The cells seem to be secretion globules of some kind that function in separating off the old epithelium and in bringing about its digestion or dissolution. Of course, small droplets may be formed during its disintegration.

In criticizing vom Rath's work Verhoeff assumes that if every epithelial cell divides to form an old and a new layer then the leucocytes must be in the inner layer. He says this is not the case because most of the leucocytes are found between the two layers, therefore regeneration as in the insects is not possible in Diplopods.

In *Euryurus* the bodies are formed in the inner layer by amitosis during and after the time when old epithelium becomes separated and thus are located in and between the two layers. They are largest between the layers. No sections have shown that the entire thickness of the mid-intestinal wall is thrown off, in *Euryurus*, and a new layer regenerated from primary leucocytes during moulting, as Verhoeff appears to claim is the case in *Polydesmidæ* and *Iulidæ*. Possibly Verhoeff's supposed leucocytes are similar to the small cells budded off in *Euryurus* from the epithelium and the latter is regenerated from primitive epithelial cells, and not from primary leucocytes. In *Euryurus*, digestive cells are rapidly used up during digestion and consequently during the feeding condition are being replaced from time to time from primitive epithelial cells. Verhoeff (1914) in his work on *Polydesmus* observed mid-intestinal transformations and found cells in all stages of development between the compressed and tongue-formed cells. It seems that he has made wrong interpretations in a number of cases. His observations are in favor of epithelium being replaced by primitive epithelial cells.

In *Euryurus* there is an exceedingly large formation of the bodies in animals which have just shed their old exoskeleton and the new chitin is still as soft as rubber. These animals are easily sectioned or dissected.

Sections showed that the spheres are not tremendously abundant until the animals are ready to shed their old skin. The spheres are of various sizes, without clearly defined nuclei if present at all. Most of them are single but many are in clusters.

Shortly after the old exoskeleton is shed the recently moulted specimen starts consuming it unless disturbed. In some cases all of the old chitin is consumed. When the first exoskeletal piece is swallowed there starts a new period of important changes in the mid-intestine.

In *Euryurus* during a part of the moulting period the mid-intestine is closed in front and behind. This reopens when ecdysis is complete, but is an obstruction to the first piece of exoskeleton. This obstruction is overcome more readily as the new mid-intestinal cuticula is formed, which separates it from the new epithelium. The exoskeletal pieces pass through the oesophagus and, in the mid-intestine, push the loosened container posteriorly.

In a specimen of *Euryurus* which had eaten about one-half of its old exoskeleton, this container was pushed back to the rear half of the mid-intestine.

Verhoeff has made similar observations in *Julidæ* and *Polydesmus*. He describes what he calls a white body and a yellow body with a yellow layer which corresponds probably to the old epithelium judging from his criticism of vom Rath's work. The yellow body described by Verhoeff in "Die Diplopoden Deutschlands" Fig. 44, page 603 corresponds to the central portion of the lumen inside the old epithelial ring in *Euryurus*, and the white body that space between the cuticula and the old epithelium. This latter space is filled, in *Euryurus*, with spherical bodies of various sizes.

Verhoeff (1914) described, in the diminishing white body, leucocytes

varying much in shape and position, with larger nucleated ones between smaller non-nucleated ones.

The yellow body is described by Verhoeff as being composed of numberless leucocytes and full of fluid. In *Euryurus* very few bodies were usually observed in the central part of the lumen inside the old epithelial layer. The largest spheres were in large masses outside the inner layer. Smaller ones were scattered or in rows through the epithelium and dividing by amitosis inside cells, indicating their functioning in its dissolution and digestion. Perhaps true digestive cells from (H) shown in Plate II, Fig. 3 digest some or all the bodies formed from the inner layer.

The epithelium of *Euryurus* soon after ecdysis assumes a typical feeding condition, as the cells are elongated and over them collect numerous round, small digestive globules which Verhoeff says are forerunners of the new primary leucocytes from which the epithelium is formed.

The reason Verhoeff gives for the disintegration of the white body is that the larger leucocytes ingest the smaller ones and at the end of this process the yellow body tube is pushed into the lower intestine.

The old epithelial cells (yellow layer of Verhoeff) seem to serve as nourishment for the new cells in *Euryurus*. These new cells start to form and function shortly before the shedding of the exoskeleton judging from numerous slides and dissections showing the spheres or secretion globules in abundance at this time and in greater quantities after the shedding and eating of the old chitin.

In a specimen of *Euryurus* which had almost totally ingested its exoskeleton the front part of the mid-intestine did not contain pieces of the exoskeleton in the cuticular tube. The epithelial cells were rod or tongue shaped and cells in various stages of development were found between them.

In Plate II, Fig. 3, the epithelial cells are very compact. At this stage after the ingesting of the exoskeleton the cells were less compact.

There were fewer of the cells formed from the inner layer in the lower half of the mid-intestine. The anterior two-thirds of the hind-intestine contained a number of exoskeletal pieces. Gregarines were found in the hind-intestine during this period. Before moulting they are found in the mid-intestine. Some parasites may thus be eliminated during moulting.

The Transition From the Mid-Intestine to the Hind-Intestine and a Discussion of the Hind-Intestine.

The hind-intestine is set aside from the mid-intestine by a fold of tissue (RF) which may be compared with the pyloric valve of insects. Possibly it is not a true valve in the sense that it closes the tract at this point but it is a fold of tissue marking the transition from the mid-intestine to the hind-intestine. (Plate I, Fig. 6 and Plate III, Fig. 4 and 4-C).

Sections from several different specimens showed the form of the folds to vary to some extent, but the general form is shown in Plate I, Fig. 6.

The transition from the rod-shaped epithelial cells of the mid-intestine to the epithelium of the hind-intestine is shown. The epithelium of the latter soon becomes lower. The chitinous intima first appeared at the beginning of the anterior face of the fold. Numerous small longitudinal folds and depressions were noticeable over the fold but posteriorly these were much larger. The epithelial cells are elongate and rather regular. In some sections considerable striated longitudinal Muscle was evident, and fibers of longitudinal muscle extend into the fold. The cuticular striated border extends from behind the fore-intestine for a certain distance into the hind-intestine.

Verhoeff (1910-1915) designated a second cuticula which he called "Einsätzrohr." He shows no drawing of it. Nothing similar has been observed in *Euryurus* nor by Randow (1924) in *Julidæ* or Effenberger (1909) in *Polydesmus*.

Both primary and secondary intimas are clearly evident. No spines were observed on the primary intima.

The epithelium is continuous from the mid-intestine to the hind-intestine. The digestive epithelial cells cease, as one might expect, at the point of the beginning of the fold or the valve and the point where the intima of the hind-intestine begins. At the beginning of the fold the epithelium was distinctly different from that of the mid-intestine. The cells were elongate and rather regular. The basement membrane appeared to be continuous from the mid-intestine to the hind-intestine. The circular muscles appear to be continuous from the mid-intestine to the hind-intestine. They are more numerous in the hind-intestine. With the beginning of the fold there appears a heavy set of longitudinal muscles in contrast to the scattered outer longitudinal muscles of the mid-intestine.

There is just one set of longitudinal muscles in the hind-intestine. They are thicker in the region of the valve and not a thin continuous layer from the mid-intestine to the hind-intestine. Posterior to the fold the longitudinal muscles were evident as a thin incomplete layer.

The histological structure of the region a little anterior to the entrance of the Malpighian tubules is shown in Plate I, Fig. 7. Both primary and secondary intimas are present. The former is much thicker than the latter and is almost transparent and has spines projecting posteriorly for a short stretch of the canal. The groove in which each Malpighian tubule has its outlet has been previously described for *Polydesmidæ* and *Julidæ*. This groove (UC) just anterior to the entrances of the Malpighian tubules is shown for *Euryurus* in the same figure. It varies from previous descriptions for either *Polydesmidæ* or *Julidæ*.

The epithelial cells appear as elongate areas which remain almost clear and with some vacuole-like spaces after staining with Harris's haemotoxylin and eosin. The basement membrane is clearly evident and the nuclei are near it.

The circular muscles are confined to an area between the epithelium and the incomplete layer of longitudinal muscles. The circular muscle layer becomes gradually thicker.

The sphincter-like constriction, a condition observed a short distance

posterior to the entrance of the Malpighian tubules is shown in Plate I, Figs. 9 and 10 and Plate II, Fig. 5. The details of structure can best be seen in Plate I, Fig. 10. The epithelial cells are smaller than in the preceding region. Small spherical light spaces or tracheoles surrounded by darkly stained outer borders were observed, indicate as (TR). A primary intima and a basement membrance were observed. The layer of circular muscles is thick and external to it are somewhat scattered longitudinal muscles.

Nothing was found comparable to the intestinal valve in the intestinal tracts of insects. A longitudinal section through a portion of the hind-intestine characterized by minute dark brown papillæ-like structures or folds (FC) is shown in Plate I, Fig. 15. A cross section is shown in Plate I, Fig. 11. Thin primary and secondary intimas appear to be present. The epithelial cells are somewhat elongated and regular and many are characterized by lightly stained areas. The circular muscle layer is much thinner and a few scattered longitudinal muscles are present.

The fold chamber narrows and the pre-anal constriction (PAC) is the next region observed. Randow (1924) described six longitudinal folds and smaller folds in between for *Julidæ*. The epithelium is lower in a region posterior to the fold chamber (FC) and gradually increases in height in the pre-anal constriction and continues to the rectum.

In *Euryurus* the pre-anal constriction is characterized by an increase in the number of the circular and longitudinal muscle layers.

Rectum.—The intima of the rectum has folds as shown in Plate I, Fig. 12. These almost close the lumen of the gut. From Plate I, Fig. 3, its detailed structure can be deduced. The intima is distinct and slightly roughened but no spines were observed. The epithelial cells are elongate and rather regular, in comparison with low cells described in *Julidæ*. Longitudinal muscles extend to near the rectum. Circular muscles only are found in the region of the rectum.

Malpighian Tubules.

Two long and thread-like Malpighian tubules are present, attached to the alimentary canal slightly posterior to the point of transition from the mid- to the hind-intestine. The tubes pass cephalad, one on either side of the intestine, and are characterized by convolutions. They end blindly in the body cavity, attached to tracheæ. The blind ends are smaller than those attached.

Histologically, it was found that the intima is thin and irregular. (Plate I, Fig. 7). The epithelium consists of rod-shaped cells with darkly stained nuclei which make up the greater part of the wall. A basement membrane is present and muscular layers absent.

Studies on Internal Anatomy in Addition to Those on the Alimentary Canal.

Glands.

The glands of *Polydesmus* have been studied by Effenberger (1909), Verhoeff (1910-1915) and Attems (1926).

Those of *Iulus* have been studied by Plateau (1878), Silvestri (1902), Rossi (1902), Krug (1906), Wernitzsch (1910), Verhoeff (1910-1915) and Attems (1926).

Effenberger (1909) has a good review of the literature on glands of *Iulidæ*. He reported many similarities between the glands of *Iulidæ* and *Polydesmus complanatus*.

The pair of tubular glands of *Euryurus* have the outlets of the ducts the same as in *Iulus* and *Polydesmus* but the glands show a different structure than previously described. (Plate II, Fig. 8). Effenberger (1909) in his Figure 9, on page 569 shows the gnathochilarium with the ducts of the tubular glands. The ducts run between the stipites gnathochilarii and the lamella linguales or according to vom Rath, using Latzel's terminology, between the mala gnathochilarii and the lobi linguales.

Three "traubigen Drusen" or grape-like glands were observed in *Euryurus*. Two have been reported for *Iulus* and *Polydesmus*, namely front and hind salivary glands. In *Iulus* and *Polydesmus* the lower pair of salivary glands are united to form a single glandular mass with the duct outlet between mandible and hypopharynx. In *Euryurus* they (SG) are separated and lie on each side of the oesophagus. (Plate II, Figs. 7 and 8). These are similar in *Craspedosoma* described by Wernitzsch (1910).

Plateau (1878), Rossi (1902) mistook the glands for fat bodies. Also Bruntz (1904) is mistaken regarding the true nature of the lower salivary glands as he associates them with the tubular glands.

The third "traubige Druse" present in *Euryurus* is the "vordere Speicheldruse" or "Kopfdruse," or head gland, as it may be called due to its position and has been described in *Iulus* and *Polydesmus*. It lies in the head over and in front of the brain, which is above the mouth opening. The ducts have their outlets about in the mid line of the dorsal part of the mouth.

Rectal glands or "Afterdruse" in females and "Saftdrusen" or odoriferous glands are described for *Polydesmus* by Effenberger (1909). They are essentially the same in *Euryurus*. The distribution of the repugnatorial pores was described by the writer (1927).

Musculature.

1. *Body*.—The body musculature of *Euryurus* appears to be rather simple. Muscles in the right half of a body segment are shown in Plate III, Fig. 6. In each double segment three paired sets of muscle are found, namely, two dorsolateral, longitudinal bands (DMCL) from the intercostal ridge (AC) of one segment to that of the next; a pair of lateral muscles on each side (LMCL); and a pair of slender ventral muscles (VMCL).

2. *Leg*.—The segments have been numbered I to VII. (Plate III, Fig. 7). They correspond with the segments of the insect and chilopod leg, as given in a paper (p. 93) by Snodgrass (1927). The number holds almost without exception (i.e., the number of segments with muscles) in all the Arthropod groups, but the nature of the articulations and the musculature differs.

Insects, Chilopods, and Diplopods lack a levator of the dactylopodite, or claw. Crustacea and Arachnids have both levator and depressor muscles of the dactylopodite, or claw-bearing segment. The musculature of the left leg of *Euryurus*, as determined from an anterior view, is as follows:

A. Promotor of I (Coxa).
B. Remotor of I.
C. Levator of II.
D. Anterior depressor of II.
E. Posterior depressor of II.
F. Levator of III.
G. Depressor of III.
H. Levator of IV.
I. Depressor of IV.
J. Levator of V (posterior).
K. Depressor of V (anterior).
L. Depressor of VI.
M. Depressor of VII (dactylopodite).

3. *Mandible.*—This is complicated and difficult to study in *Euryurus*. The large local millipede *Spirobolus marginatus* was also studied because it is much easier to work with, due to its size and flexible body wall. Snodgrass has studied a large *Julid* from Siam. Thus, comparisons of the mandibular musculature of three forms have been made. It is believed that this musculature is essentially the same. Plate III, Fig. 5, is a drawing of the outer view of the left mandible of *Euryurus*. Figure 5-A is a dorsal view of the left mandible of a large *Julid* from Siam (after Snodgrass).

The mandible (MD) consists of two basal plates inserted into the head wall, and a distal, movable functional mandible. The basal plates have three muscles: (1) a large dumb-bell shaped muscle arising in the hollow of the basal plates on each side and continuous through the head by a thick, median transverse tendon. This muscle is lacking in Chilopods and insects but is characteristic of the more generalized Crustaces, including *Apus*. From the first basal plate a large muscle (2) goes to the bar at the sides of the mouth (suspensorium of hypopharynx). This muscle, according to Snodgrass, is present at least in *Machilis* and some Orthoptera. The third muscle (3) is a retractor, or promoter, of basal plate arising on the back of the head. The movable part of the mandible has a small adductor (4), in figure 5-A, going to the basal plate, and a large adductor (5) to the posterior dorsal wall of the head. Abductor muscles were not found and the mechanism by which the mandibles are opened is not known. The mandibular muscles appear to comprise crustacean and insect muscles and no account of them has been found.

The Nervous System.

The previous workers on this system in Diplopods are Newport (1843), Rossi (1901), Verhoeff (1910-1915) and Attems (1926).

The central nervous system of *Euryurus* consists of a brain or cerebral ganglion, suboesophageal ganglion and a ventral nerve cord with ganglia and nerves.

The brain of *Euryurus* consists of two main lobes separated by a slightly constricted area. (Plate III, Fig. 3). In the side view diagram, of course, this area does not show.

Antennal nerves are present. Optic nerves are absent, there being externally no organs of vision. The cerebral ganglia are connected to the sub-oesophageal ganglion (SG) by a circum-oesophageal con-

nection (CC). A single pair of legs is found on the first, third, and fourth segments of all the stages, and the second trunk segment lacks limbs in every case in *Euryurus*. A single ganglion (G) and two pairs of nerves (LN), (DLN) were found in the above-mentioned trunk segments.

The fifth trunk segment, as shown in the diagram, and all the succeeding trunk segments except the anal segment have two pairs of limbs. The gonopods of the male are modified from the eighth pair of legs on the seventh body segment. Two ganglia and three pairs of principal nerves were found in these segments. One pair of nerves runs dorsally, and the other two pairs run ventrally, each supplying a pair of legs.

The nerve cord is double and separated by more or less distinct strands with ganglionic swellings in each segment, which are connected by cross commissures.

In their following course both strands fuse to a greater or lesser extent into an uneven branch which is surrounded by the perineural sinus. (PNS) shown in Plate II, Fig. 7. The dorsal part of the branch is surrounded by the supraneural septum, its sides by the slanting muscles of the leg and ventrally by epithelium. The development of the supraneural septum has not been observed yet. The nerve cord rests upon a network of fat cells, part of which later are located between the epithelium and nerve cord when the cord is separate from the epithelium. Upon the ventral surface of the supraneural septum are found phagocytic organs (Bruntz 1906) and upon the dorsal are nephrocytes.

Rossi (1901) states that the ventral nerve cord of *Julus terrestris* is without ganglia, commissures and connections. He describes four pairs of nerves for each movable segment.

Newport (1843) describes in detail and illustrates in his Plate XI, Fig. 6, the central nervous system of *Polydesmus complanatus*. He states that the ganglia of the first two pairs of legs have united with the first suboesophageal ganglion. In *Euryurus* this was not the case as a single ganglion and two pairs of nerves were found in the first, third and fourth trunk segments.

Otherwise conditions in *Euryurus* are comparable to those described for *Polydesmus*.

The Tracheal System.

Many investigations have been made on the tracheal system in Diplopods. Rossi (1902) gives a detailed historical review of previous work. Wernitzsch (1910) adds additional references up to the time of his observations. He compares the tracheal system of *Craspedosoma* with that of other Diplopods (*Heteroporatia*, *Glomeris*, *Polydesmus*, *Iulus* . . .). More recent work is as follows: Verhoeff (1910-1915), Attems (1926).

Wernitzsch (1910) states that the tracheal system of Diplopods is of especial importance because it connects primitive conditions as found in Peripatus with the more complicated conditions in Chilopods and insects. The very fine unbranched tracheæ originating out of the tracheal pockets are similar to those of Peripatus and the tracheal

pockets are homologous to the ectoderm tube of Peripatus (Ziegler 1907). In many Diplopods, for example *Glomeris*, the trachea are similar to those of insects (Voges 1878).

The tracheal system of *Polydesmidæ* is considered in brief by Attems (1927) and in greater detail by Effenberger (1907) and Verhoeff (1910-1915). Verhoeff disagrees in certain points with Effenberger.

The writer has not worked out the complete tracheal system of *Euryurus*, nor checked contradictory points, however, a few observations follow, all of which are similar, in general, to those of others made on different *Polydesmidæ*. An adult *Euryurus* has twenty trunk segments. One tracheal system consists of a stigma, tracheal pouch and tracheæ and tracheoles. Stigmata were not found in the nineteenth and anal segments nor in the first, second and third segments.

One large tracheal bundle leaves a large tracheal pocket on each side of the anterior part of the sternite of the fourth segment. Each large bundle goes to the side of the head. A smaller bundle leaves each side of the anterior pocket of the fifth sternite. These latter bundles run anteriorly under the larger bundles and converge towards the mid-line of the head. Thus these bundles run anteriorly and supply the anterior segments and the head region.

In *Polydesmus* and *Craspedosoma* two pairs of longitudinal bundles run to the head region.

All investigators except Visart (1894) state that the tracheæ never bifurcate nor anastomose. Visart erroneously mentions and illustrates some tracheæ branching in the intestine of *Julus*.

The Reproductive Systems.

1. *Female.*—On the dorsal wall of the ovarial sack in *Euryurus*, running parallel on either side of the mid-line are the ovaries (EB). (Plate III, Fig. 1-A). These ovaries are covered with numerous developing ova (DO) and are enveloped by a single very delicate, transparent covering. This covering or ovarial sack has the form of a tube pressed together in a dorso-ventral direction and is located ventral to the intestinal tract and dorsal to the nerve cord.

When the eggs are mature, they become separated from the ovaries. The ovarian sac becomes much distended and gradually the ova reach the oviduct. The mutual ovarian sac terminates in a single oviduct (O) which soon bifurcates. Each oviduct branch curves laterally, posteriorly and internally (Plate III, Fig. 1-B) and connects with a vulva.

The vulvæ are attached to the second pair of legs. (Plate III, Fig. 1-B). Each vulva is composed of the opening of an oviduct, glands, and muscles. The vulvæ usually, unless the animals are copulating or ovipositing, lie in depressions surrounded by the sternite. The proximal end of each oviduct is situated on the bottom of a vulva and enters a chamber which opens to the outside. When the vulvæ are everted, the proximal end is outermost, which is most advantageous for oviposition and copulation.

The bursa makes up most of a vulva and is located behind the opening of the oviduct. The simplest operculum (OE) is in front of

the oviduct opening. The bursa is composed of a smooth, more or less depressed zone which is called "Cimier" by French writers. It appears similar to the valves of a mussel. The middle part of the "Cimier" is depressed trough-like and forms a seminal receptacle. By older authors (Fabre, vom Rath . . .) this was mistaken for a gland. In the front part of the receptacle are real glands which were previously overlooked. According to Fabre, *Polydesmus* has no seminal receptacle but Effenberger disagrees. The front rims of the valves and the posterior rims of the operculum, between which lies the oviduct opening, are connected by chitin clasps.

The vulvæ have the form of a compressed sphere and the valves and the operculum have bristles. The bristles on the valves are found on the side towards the median crest. Strong "teeth" are present. The seminal receptacle has the form of a coiled blind sac (SR). On the distal end it is bubble-shaped. Attems (1926) mentioned its lumen being filled with numberless spermatozoa in *Polydesmus*. The bottom channel piece (Kehlstuck) is to a lesser or greater extent loose from the valves. Attems (1926) described the large double-lobed bursa glands found in the front end of the receptacle and smaller gland masses, the glands of the Kehlstuck and vulvular glands.

2. *Male.*—The reproductive system of the male is formed of two long tubes united frequently with cross connections (TC) which makes it resemble a ladder. (Plate III, Fig. 2-A). The vasa deferentia start in the seventh segment and run forward with regular anastomoses to the paired openings (VD) found on projections located on the coxal joints of the second pair of legs. (Plate III, Fig. 2-B).

Fabre (1855) reported for *Polydesmus complanatus* that transverse connections disappear at about the seventh segment. Effenberger (1909) describes the vasa deferentia starting in the seventh segment and running anteriorly to the fourth segment and uniting. They go united for a short distance, then separate in the lower section of the third segment and each branch goes to its outlet in the coxal joint of the second pair of legs.

The second pair of legs is attached to the third trunk segment. The vulvæ of the female are found in a somewhat similar position attached near the base of the second pair of legs. The "ladder" commences in the next to last segment and the tubes open on projections as previously mentioned. The number of cross connections has varied some in specimens studied. Twenty-seven are shown in Plate III, Fig. 2-A. Fabre observed sometimes 13, sometimes 14. In *Euryurus*, the testicular follicles (T) usually appear in the seventh or eighth trunk segment and continue to the next to the last segment.

Effenberger states that for *Polydesmus* the spermatozoa are small, round and not free moving cells.

The seventh segment is the important one in copulation. Its first pair of legs are transformed (described by the writer, 1927) into gonopods.

Effenberger (1909) states that the internal branch of the gonopods of *Polydesmus* contains a bubble which must be filled with spermatozoa before copulation. Fabre (1855) has described in detail the filling of

the bubbles with spermatozoa. He states that before copulation the male lifts up the upper part of the body and coils S-formed, so that the third trunk segment approximates the seventh. He also observed a sperm droplet come out of each opening of the vasa deferentia and taken up by the chitin brushes which are found on the internal branches. He further states that there is no doubt that the droplets reach the bubbles through the opening (seminal receptacle) in the middle of the hair fringe.

Many male specimens of *Euryurus* have been observed coiling S-formed but the sperm droplets have not been observed coming out of the openings of the vasa deferentia and being taken up by the gonopods.

Circulatory System.

This is not as well known in the Diplopods as in the Chilopods. Rossi (1902) reviews the work on Chilopods and Diplopods in a historical note. There are a number of contradictory points in regard to the intimate structure of the heart. Rossi recorded his observations concerning several contradictory points. The most recent work is by Verhoeff (1910-1915) and Attems (1926).

The heart (HT) of *Euryurus* lies between the dorsal epithelium and the intestine. (Plate II, Fig. 7). Its walls from outside to inside are composed of circular muscle strands, a structureless cuticle or intima, adventitious cells, and a pericardial membrane. The heart appears wave-like in longitudinal sections. Its posterior end is blind while anteriorly it opens in a short aorta. In each double segment there are two ostia, two transverse vessels with short open branches, having their outlets ventral in contractile canals. These canals are lacunæ bordered dorsally by the wall of the perineural ainus and ventrally have their own walls consisting of transverse muscle fibers.

Newport (1843), in regard to ostia, does not decide whether he is dealing with simple openings or with terminations of delicate veins. He is inclined towards the latter opinion. No venous system was observed in *Euryurus* nor did Rossi find one in *Julus*.

The research upon which this report is based was carried on chiefly at The Ohio State University during a period of two years, (1925–1927). Some observations were made at the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, during the summers of 1926 and 1927; and at the Detroit College of Medicine and Surgery, Detroit, Michigan, (1927–1930).

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EXPLANATION OF PLATE I.

(Drawings).

Fig. 1. Cross-section of oesophagus. PI.—Primary intima; SI.—Secondary intima. LM.—Longitudinal muscle. CM.—Circular muscle. E.—Epithelium. Magnification=413×.

Fig. 2. Section "A" of Fig. 1 enlarged. BM.—Basement Membrane. Magnification=825×.

Fig. 3. Longitudinal section through oesophageal valve. Mid. Int.—Mid-intestine. I. L. M.—Inner longitudinal muscle. O. L. M.—Outer longitudinal muscle. H.—Cover layer. A.—Annulus. P.—Process.

Fig. 4. Cross-section of mid-intestine of feeding animal. C. S. B.—Cuticular striated border.

Fig. 5. Section of Fig. 4 enlarged. T. R.—Tracheole. Magnification=825×.

Fig. 6. Longitudinal section through ring fold. H. I.—Hind-intestine. M. I.—Mid-intestine.

Fig. 7. Cross-section of intestine, shortly anterior to entrance of Malpighian tubules. U. C.—Urine chamber. Mpg. T.—Malpighian tubule. Magnification=825×.

Fig. 8. Cross-section through intestine where Malpighian tubules enter.

Fig. 9. Cross-section of constricted region just posterior to the entrance of Malpighian tubules. Magnification=413×.

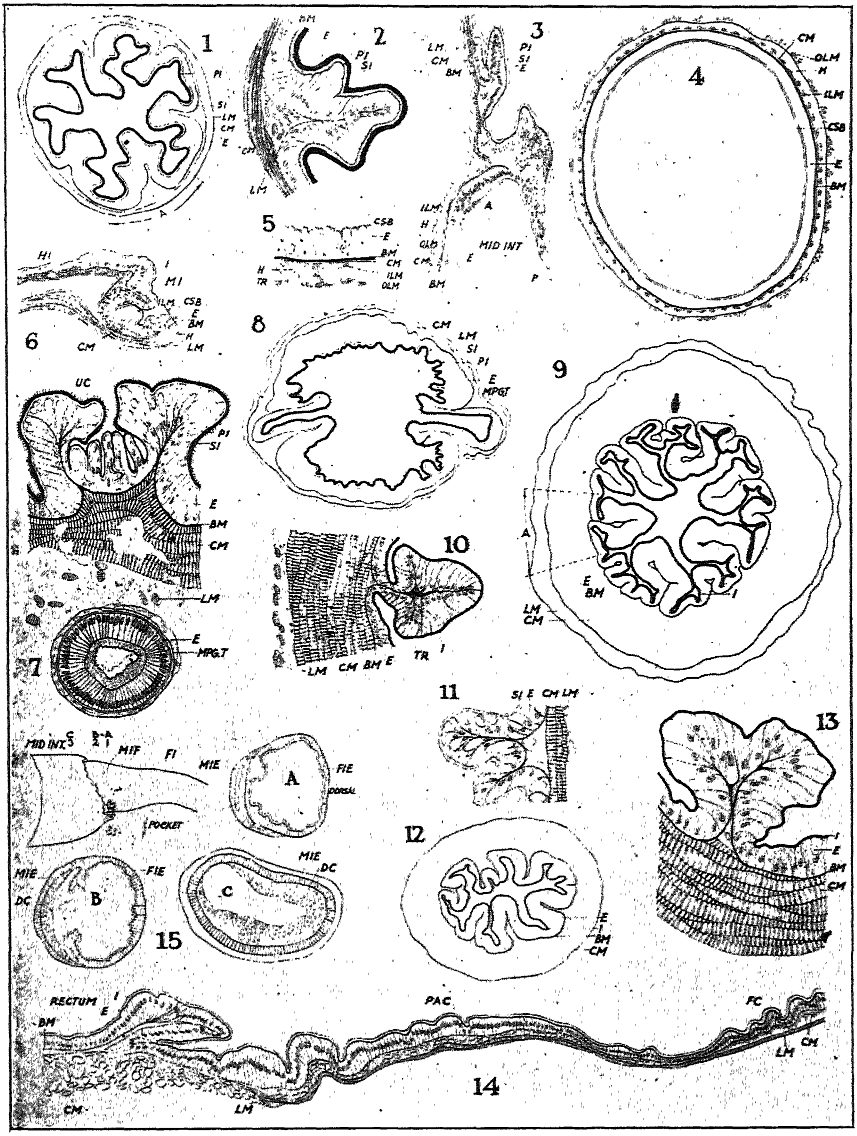
Fig. 10. Section "A" of Fig. 9 enlarged. Magnification=825×.

Fig. 11. Cross-section through fold chamber. Magnification=825×.

Fig. 12. Cross-section through rectum.

Fig. 13. Section of Fig. 12 enlarged. Magnification=825×.

Fig. 14. Longitudinal section through fold chamber, preanal constriction and rectum. F. C.—Fold chamber. P. A. C.—Pre-anal constriction.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EXPLANATION OF PLATE II.

(Photographs).

Fig. 1. Cross-section of oesophagus.

Fig. 2. Cross-section of mid-intestine of feeding animal.

Fig. 3. Cross-section of mid-intestine of moulting animal. D. C.—Cells formed in AE. A. E.—Old epithelium.

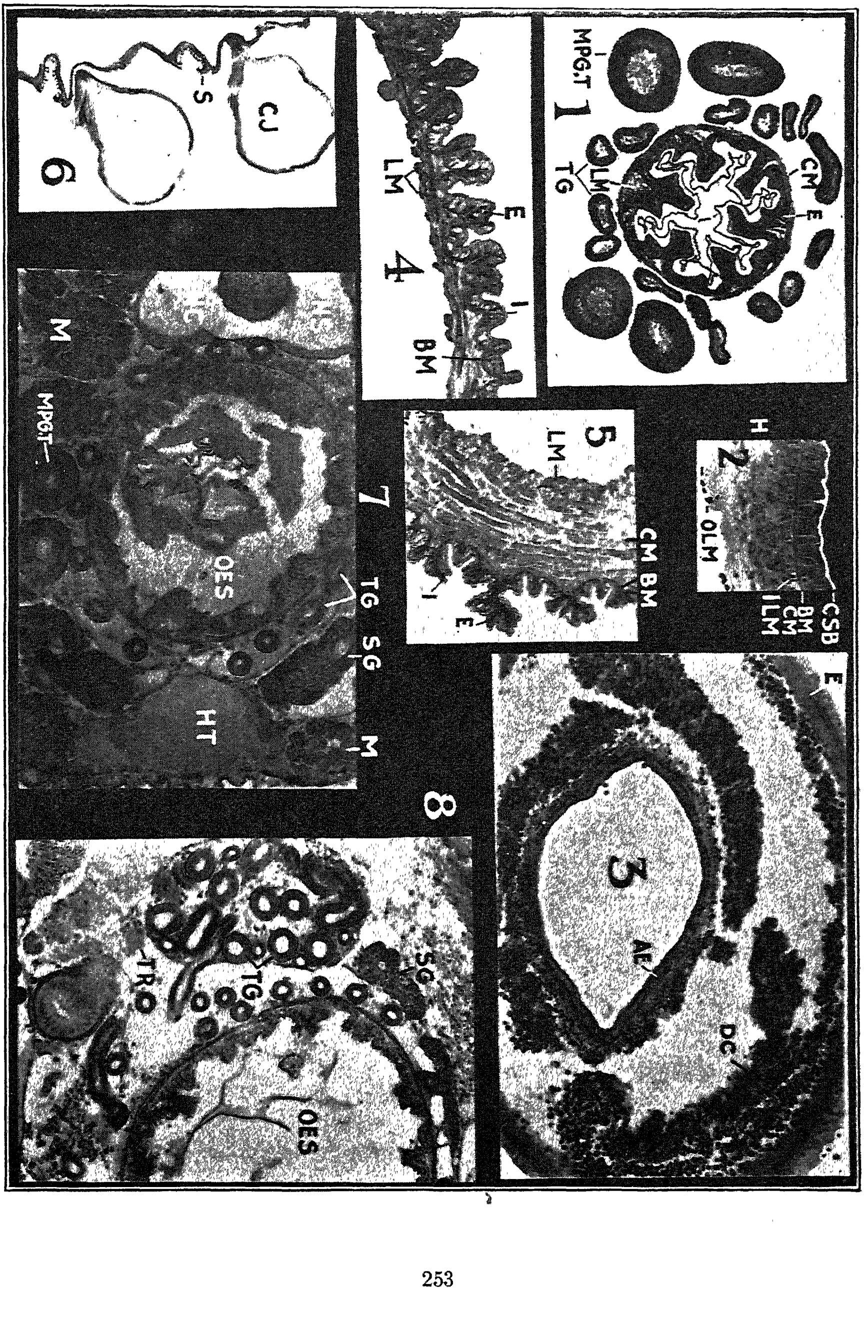
Fig. 4. Cross-section through fold chamber.

Fig. 5. Cross-section of constricted region just posterior to the entrance of Malpighian tubules.

Fig. 6. Longitudinal section through stigma and coxal joints of a segment with two pairs of legs. S.—Stigma. C. J.—Coxal joints.

Fig. 7. Cross-section through body in region of oesophagus to show relation of parts. OES.—Oesophagus. T. G.—Tubular glands. S. G.—Salivary glands. M.—Muscle. H. T.—Heart. N. C.—Nerve cord. P. N. S.—Perineural sinus.

Fig. 8. Cross-section through another portion of oesophagus, tubular gland, tracheal bundle, etc.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EXPLANATION OF PLATE III.

(Drawings and Photographs).

Fig. 1. Ventral view of adult female *Euryurus*.
Fig. 1-A. Female reproductive system.
Fig. 1-B. Second pair of legs with vulvæ and oviducts.
Fig. 2. Ventral view of adult male *Euryurus*.
Fig. 2-A. Male reproductive system.
Fig. 2-B. Second pair of legs and openings of vasa deferentia of male.
Fig. 3. Diagram showing side view of nervous system in head region and from segments 1–5, inclusive.
Fig. 4. Dorsal view of adult alimentary tract.
Fig. 4-A. Lower lip or gnathochilarium. (Labeled after Effenberger).
Fig. 4-B. Anal segment with anal plates and anal scale.
Fig. 4-C. View of portions of the inner wall of the intestine.
Fig. 5. Outer view of left mandible.
Fig. 5-A. Dorsal view of right mandible of a *Julid* from Siam. (After Snodgrass).
Fig. 6. Muscles in right half of body segment.
Fig. 7. Anterior view of left leg.

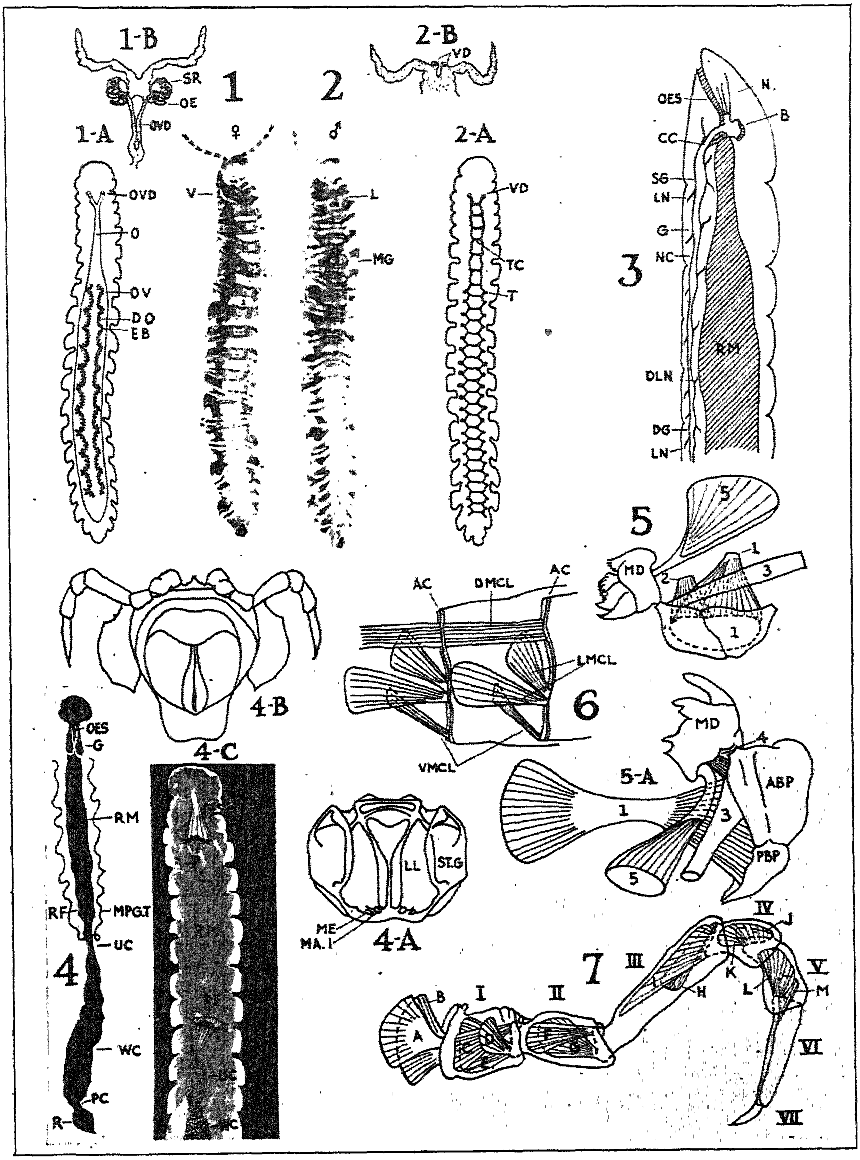
DETAILS IN FIG. 5.

1, Transverse adductor of basal mandibular plates. 2, Muscle from hypopharyngeal support to anterior basal plate of mandible (ventral to 1 in Figure 5-A). 3, Muscle from dorsal edge of mandibular plate to posterior rim of head. 4, Small adductor from mandible to mandibular plate. (Not seen in Euryurus). 5, Adductor of mandible arising on posterior dorsal wall of head.

ABP, Anterior basal plate of mandible. PBP, Posterior basal plate of mandible.

ABBREVIATIONS USED IN THE FIGURES—PLATE III.

SR—Seminal receptacle.
OE—Operculum.
OVD—Oviduct.
EB or OB—Ovary.
DO—Developing ova.
V—Vulvæ.
L—Second pair of legs.
VD—Openings of vasa deferentia.
TC—Transverse connections.
T—Testicular follicles.
MG—Male gonopods.
OES—Oesophagus.
N—Nerves.
B—Cerebral ganglia.
CC—Circumeosophageal connectives.
SG—Sub-oesophageal ganglion.
LN—Lateral nerve.
G—Ganglion in Fig. 3.
NC—Nerve cord.
DLN—Dorsal lateral nerve.
DG—Double ganglion in double segment.
RM—Mid-intestine.
G—Glands in Fig. 4.
MPGT—Malpighian tubule.
RF—Pyloric valve.
UC—Urinary chamber.
WC—Fold or wrinkled chamber.
PC—Pre-anal constriction.
R—Rectum.
LL—Lamellæ linguales.
STG—Stipes gnathochilarii (Stammteil).
ME—Mala exterior (ausere Lade).
MAI—Mala interior (innere Lade).
AC—Antecostal ridge.
DMCL—Dorso-lateral longitudinal bands.
LMCL—Lateral muscles.
VMCL—Ventral muscles.
MD—Mandible.
I-VII—Divisions of leg.
A—Promotor of I (coxa).
B—Remotor of I.
C—Levator of II.
D—Anterior depressor of II.
E—Posterior depressor of II.
F—Levator of III.
G—Depressor of III.
H—Levator of IV.
I—Depressor of IV.
J—Levator of V (posterior).
K—Depressor of V (anterior).
L—Depressor of VI.
M—Depressor of VII (dactylopodite).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THE INFLUENCE OF CLIMATE ON HUMAN ORGANISM AS EVIDENCED BY THE DEATH RATE FROM CERTAIN DISEASES, AND BY CONCEPTION RATE.*

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Little effort has ever been made to ascertain in any detail the biological influences which climate may exert upon the human race. Certain differences between people of different countries have been recognized and classed as racial or environmental in origin, but no serious effort has ever been made to see how much is due to the climatic factor alone. Huntington (1) has presented perhaps the most interesting observations and theories along these lines, showing climate to be very important in the development or regression of peoples. It still remains, however, to establish the more exact manner in which man is thus influenced.

During a two years' sojourn in north China, the writer became much interested in the possible physiological effects of the intense and constant moist heat of their tropical monsoon summer period, which extends practically to the Arctic circle. The people of China, from Canton in the south to Mukden in the north, have been found to consume oxygen at a rate about 10% less than that of people of Europe and northern United States, their blood pressure is about 10% lower, and various other measurements show a level of physical activity distinctly below our accepted western standards. Westerners staying two years or more in China often suffer a distinct fall in blood pressure, while Chinese coming to Europe or America show a rise in pressure and energy expenditure.

In addition to these physiological differences which seem to result from prolonged residence in the Orient, it was observed that the incidence of certain metabolic diseases, such as diabetes mellitus, pernicious anemia and exophthalmic goiter, was very low among the natives, and of mild form when present. Arteriosclerosis with hypertension was also very infrequent, which

*Presented at the meeting of the Ohio Academy of Science, April 18, 1930.

would fit in well with the general low level of blood pressure. In other words the very diseases which are increasing at such an alarming rate in America, are very mild or non-existent in the Orient. This raised the question as to what factors could possibly be responsible for such differences.

As a starting point for a study of this question, I collected statistics on the death rates for various diseases in all possible countries, and in the different states of this country. Recognizing that mortality statistics can be no more reliable than is the ability of the physician signing the death report, still I feel that they offer at present the best information obtainable over any considerable portion of the world. The information obtained has indicated a very definite geographic, or climatic, influence at work on the mortality from these diseases.

Diabetes Mellitus.

Diabetes Mellitus, for instance has a mean death rate of 9.9 per 100,000 population in 11 southern states for 1920, 1925, and 1926, while the northern states range upward to the high point of 22.1 for New England. The cities show similar differences, ten southern cities having a rate of 14.1 diabetic deaths per 100,000 population, 20 cities through the central section from San Francisco to Baltimore with a rate of 20.4, and 26 cities farther north having a rate of 23.0. The negroes show this increasing diabetes death rate toward the north even more strikingly than does the white race. Thus the colored rate is about 4.0 in gulf states, rises to 8.2 in Virginia, 11.2 in Kentucky, 17.0 in New York, and 17.6 in Pennsylvania. In the last state named the colored rate is higher than for the white race, as is also true in Kentucky. This same difference is seen in the countries of Europe, the low rates being found south of the 50th parallel, and the high rates north. Finally, a survey of the diabetes death rate over the earth shows it to be generally low in the tropics, subtropics and Orient, and high in the cooler countries both north and south of the Equator. Australia, New Zealand and South Africa for instance have high rates such as are seen in northern Europe, northern United States and Canada.

Pernicious Anemia.

With pernicious anemia much the same distribution is found although the difference is even more striking. In the

southern states the rate is 2.1 deaths per 100,000 population while the rate in the north is 6.8, rising as high as 10.4 in Iowa. The rate throughout the tropics and orient is very low, while in the cooler countries both north and south the rate is high and was rapidly increasing up to the advent of liver therapy in 1926. Since then it has been decreasing in the countries with the high rates.

Exophthalmic Goiter.

With exophthalmic goiter the story is slightly different. Although there is the same difference between northern and southern states, with a mean rate of 4.0 in the north and 1.5 in the south, there is also found a low rate in all states bordering on the Atlantic ocean, even including Maine. On the Pacific ocean the rate is high. This same oceanic effect is found in the provinces of Canada. Further search will be made for the explanation of these findings. Over the rest of the world we find a low death rate from exophthalmic goiter in the tropics, sub-tropics and Orient, and a high rate in the cooler countries. Jamaica provides an exception worthy of note. Although located in the tropics, it has headed the list of countries with high goiter death rates for the last few years. Previous to about 1924 it had practically no deaths from exophthalmic goiter.

Addison's Disease.

Deaths from Addison's disease number only 0.1 per 100,000 population in our southern states as contrasted with 0.5 in the rest of the country. The other countries of the earth show the same climatic differences as were seen for the other diseases. Jamaica, however, again comes high in the list, quite out of its class as a tropical country.

Angina Pectoris.

The death rates for angina pectoris were taken as a rough index of the blood vessel changes and blood pressure. It was noted in China that arteriosclerosis and hypertension occur with much less frequency than in America, and that the mean blood pressure of the people is distinctly lower there. The blood pressure of foreigners going to China falls slightly after a residence of more than two years there, but rises after returning home. It was, therefore, thought that it would be of

interest to study the death rate from angina pectoris under different climatic conditions.

In our southern states its death rate is 9.8 per 100,000 population as contrasted with a northern rate of 18.6. In various countries over the earth the rate is generally low in the warmer latitudes and high in the cooler regions. Again Jamaica is high in the list of countries with high rates. It will be of great interest to ascertain what change has taken place in this island in the last 6 or 8 years that might be responsible for its high death rate from exophthalmic goiter, Addison's disease and angina pectoris. Japan and North China on the other hand, although placed well north, have truly tropical rates for all these metabolic diseases. This may perhaps be due to the tropical summers which they must endure.

Human Fertility.

In attempting to determine the effect of climate on the sex glands, recourse was had to the birth statistics in various regions. The numbers of births in each month for any locality were obtained, the months equalized to a 31 day basis, and the time of conception calculated by counting back 9 months and 10 days. The variations in the conception rate thus obtained were studied in relation to the mean monthly temperature, rainfall and relative humidity.

In the northern countries and states, where the winter temperatures are low and the mean July and August temperature does not rise above 70° F., the conception rate is low in late winter rises through April, May and June, to a summer peak, and falls gradually through the fall months. This applies, for instance, in such countries as Canada and the Netherlands, and in the state of Maine. As we go further south and the mean temperature rises above 70° F., a slight summer depression in conceptions occurs which becomes more marked the higher the mean summer temperature goes. In such cities as Charleston, South Carolina, and Tampa, where the mean temperature rises to 82° F. and 83° F. for the summer, there occurs corresponding depressions of 27% and 31% in the conception rate for the heat period.

In Japan the conception rate is exceedingly high for the three spring months from March 15th to June 15th, but then suffers a 50% reduction through the succeeding three months of summer heat and constantly high humidity. Dr. T. J.

Le Blanc obtained data on the use of houses of prostitution in Japan throughout the year, and found no reduction in this evidence of male sexual activity during the summer months. Since in Japan the male sexual activity would dominate the picture so far as frequency of intercourse is concerned, we may infer that the marked reduction in summer conceptions represents a reduction in fertility of the population. Less than 10% of the spring increase in conceptions in Japan could possibly be attributed to the spring increase in marriage rate. In Switzerland, for instance, there is a second marriage peak in the fall which is accompanied by no increase in the conception rate. Therefore fluctuations in the monthly marriage rate are not an important responsible factor in the conception rate changes. It would seem fairly certain, then, that we are dealing with real changes in human fertility.

It is of interest to note that, not only do mean temperatures above 70° F. depress fertility, but those below 40° F. act likewise, and around 65° F. is always found the highest conception rate for the year. Huntington, studying human efficiency in various fields of endeavor, arrived at 64° F. as the optimium temperature for maximum efficiency.

Conclusions.

In conclusion, then, it seems evident that climate does exert a distinct effect on the activity of the endocrine glands, and through them it markedly influences the death rate from the metabolic diseases. The most stimulating climates and those leading to highest human efficiency, are also those where the over-stimulative or exhaustive diseases are most prevalent and most rapidly increasing. These facts should be recognized and proper steps taken to control the high rate of metabolic breakdown in the cooler climates. The northerner living a high-pressure life should go to Florida, not in February when the climate there is most stimulating, but in mid-summer when it is most depressing to the metabolism. It would seem probable that certain portions of the human race are trying to live beyond their metabolic possibilities.

NOTE:—A more detailed consideration of the various phases of these statistics will appear in issues of the Archives of Internal Medicine.

REFERENCE.

(1) Huntington, Ellsworth, "World Power and Evolution," Yale University Press, New Haven, 1920, page 230.

PRINCIPLES OF PLANT TAXONOMY. IX.*

JOHN H. SCHAFFNER.

In the eighth paper† of the present series, a general synopsis of the Thallophyta was given, together with a diagramatic "tree" of relationships of the orders recognized. Since the fungi are of special importance and are thus often studied independently of other groups and since the true fungi evolved a distinctive type of plant body and cell constitution, the following analysis is presented as a partial explanation of the arrangement of the groups in the synopsis. Special attention has been given to the development of correct interpretations of life histories in the light of special studies on the problem of sex in plants in general as well as comparative studies of life cycles.

THE FOUR GENERAL TYPES OF FUNGI.

If we use the term Fungi to include all Thallophytes without chlorophyll, then these plants fall into at least four distinctive, fundamental groups or great phyla. The various kinds of bacteria, including the slime bacteria (Myxobacteriales), show a very profound segregation from the remaining groups and are closely associated with the blue-green algæ in the Schizophyta.

The saprophytic slime-molds constitute a very distinct phylum of their own, whose nearest relatives are probably to be found among the Rhizopoda of the animal kingdom on the one hand and among the Archemycetæ on the other, especially the Plasmodiophorales. But they are, nevertheless, so widely divergent from either of these groups that they are best considered as a distinct phylum which has evolved along its own lines from a very primitive starting point.

The two classes, Archemycetæ and Monoblepharideæ, show a decided correspondence to various groups of the great mother phylum, the Gonidiophyta consisting mostly of flagellate green algæ. They appear to be members of this group which have lost their chlorophyll. These two classes differ in various respects from the true fungi (Mycophyta). The Archemycetæ

*Papers from the Department of Botany, The Ohio State University, No. 256.
†Principles of Plant Taxonomy, VIII. Ohio Journal of Science 29: 289–299.

have nothing that can properly be called a mycelium. They range from forms apparently without sex, but which may nevertheless have this potentiality, to forms with well developed sexual conditions. The conjugations of the sexual forms are, however, of the more primitive and normal types of sexual fusions and not the highly specialized condition of the Mycophyta. The Monoblepharideæ are plainly a direct offshoot from the Siphonocladales of the Gonidiophyta and have the sexual processes which are typical for the higher green algæ. A *Monoblepharis* is simply a green alga that has lost its chlorophyll, in the same general sense that *Cuscuta* and *Monotropa* are Angiospermæ that have lost their chlorophyll.

The remaining chlorophylless thallophytes are the true fungi and make up the phylum Mycophyta. This phylum is characterized by its peculiar vegetative body, the mycelium, and by a specialized sexual process, the conjugation nearly always taking place between the walled sexual cells or branches. Such a process occurs only in one other group, the higher Zygophyta, with which the fungi show no close correspondence otherwise. The Mycophyta are also to be derived from the great mother group of green algæ, the Gonidiophyta. The correspondence in the original life cycle and filamentous body is very great. The normal green alga has a simple haploid sexual cycle, the only diploid nucleus being in the zygote. The true fungi have exactly this cycle at the lower levels and the higher forms have evolved a direct modification of it. There is no correspondence with any other of the higher thallophyte phyla. Neither the red or brown algæ nor the Charophyta whose life histories have been worked out have such a life cycle. The supposed correspondence of some fungi with the red algæ is entirely superficial. Fungi could not be derived from red algæ without a complete recreation of almost the entire ontogeny. Whether one derives the Mycophyta by a separate line from the green algæ or through a series of Archemycetæ is of no fundamental phyletic importance since in either case the primary derivation must be from the green-algal complex.

The Mycophyta fall immediately into two very distinct subphyla, Phycomycetæ and Mycomycetæ. The first group is cenocytic, the second has a mycelium of normal cells although cenocytic developments may be present. Now we can derive these two groups independently from the green algæ, the first

from the cenocytic Siphonocladeæ, the second from the Conferveæ. Or what is just as reasonable from the present evidence, we can say that they had a common origin as fungi, and then after being segrated from the algal line as chlorophylless plants they divided into two phyletic series in the same way as the green algæ, divided into cenocytic groups and groups which have their filaments made up of normal cells.

At the transition from green plants to typical Mycophyta the fungi were probably still isogamous or nearly so and then evolved to various degrees of heterogamy. The progress of the sexual condition was influenced by several peculiar developments which led away from the typical course of sexual evolution as it appeared in the main line of plants from the green algæ to the seed plants.

In some of the lower groups of fungi zoospores are characteristic cells of the life cycle in others and in all of the higher fungi no zoospores are in evidence. Here again we can have the choice of two alternatives in speculating on phyletic origins. For just as some green algæ in a water habitat have zoospores and some have not and the same in respect to the two great phyla of Phaeophyta and Rhodophyta, so our ancestral Mycophyta may all have had zoospores and then mutated into nonmotile forms after or at the time they took up an aerial life; or they may have developed the two types of motile and nonmotile spores and gametes before they passed from the water, if it is true that they became fungi before taking up an aerial life. It is perfectly evident that the absence of zoospores in a group is no criterion for assuming that such absence is the result of aerial conditions.

In general, the lower fungi have a loose undifferentiated condition of the mycelium while as one ascends the scale a more and more complex body is evolved, until the truly marvelous is reached in the higher Pezizales and Phallales. This complex interacting system has thus taken the same general course and direction as that which has evolved in the solid aggregates of the higher, vascular plants. But the development of complex tissue systems and organs in the fungi appears much more remarkable because the unitary interaction is accomplished through a branching system of filaments rather than in the closely packed contiguous cells of a solid tissue. Along with the development of a complex interaction and correlation system goes the development of diverse chemicals, colors and

substances, duplicating in a remarkable manner the same evolutionary movements in evidence in the higher vascular plants.

The phylogenetic movement in the rusts is in evidence not so much in the evolution of the plant body as in the complexity of the spore forms. The Teliosporæ, therefore, make up a phyletic line which advanced in a different direction from the typical Basidiomycetæ.

There are several difficult problems which come in with a consideration of the Laboulbenieæ. These plants must have segregated as a distinct phyletic line from the primitive Ascomycetæ almost from the beginning and have therefore both a peculiar fungous body (which can hardly be called a mycelium) and some very distinctive reproductive characteristics. Apparently the life cycle is the typical simple haploid sexual cycle and the slight superficial resemblances to certain features of the red algæ must be regarded like other accidental mimicries, which indicate neither phylogenetic relationships nor even a common causal basis. The development of conidia in the male reproductive branches of some Laboulbenieæ as well as in some discomycetous lichens is to be explained by the assumption of the presence of hereditary factors which give a proper functional gradient in the antheridial branch so as to throw conidium-producing heredity into activity at this point. This process does not interfere with the primary sexualization of the cells involved and thus these cells act as normal male cells in reaction with the trichogyne of the ovary. In all such cases attention must be fixed on the complex of hereditary potentialties, which are thrown into activity or latency through the development of the proper physiological states in the cells involved. The plant is not built up of "bricks and boards" but by a functional process which is induced through the interaction of the hereditary potentialities, the progress of the physiological and ontological gradients in the given parts, and the influence of the immediate environment. The old morphological speculations are largely beside the mark. When for example we cause stigmas to grow out of the tips of stamens or microsporangia to develop in the walls of an ovulary, the result does not mean that these structures were ever so associated phylogenetically but simply that we have disturbed the normal functional gradients and the normal physiological states of the cells by changing the usual environment. So also in the

evolution of a series of plants, new potentialities may appear which will produce changed functional gradients and changed physiological states in the cells at the given ontogenetic point; and thus new and somewhat different expressions from the earlier ones appear.

The origin of endogenous spermatia must be regarded as a secondary development unless it is a hold-over from a more primitive condition which is not likely. It is far more reasonable to assume a secondary conidium-like development on the order of the peculiar conidia of Thielavia where they are developed in a sheath. Whatever one may conclude as to the origin and final relationships of the Laboulbenieæ, it is far better to set them aside as a distinct class from the other Ascomycetæ. This disposal will show the very decided way in which they have digressed from the other Mycomycetæ in general and from the Ascomycetæ in particular.

THE EVOLUTION OF THE FUNGUS LIFE CYCLE.

As stated above the life cycle of the typical fungi is the simple haploid sexual cycle or some direct modification of this. (See Figs. 1 and 2.) There is no alternation of generations, the only diploid cell being the zygote. (See Fig. 3.) Some phases of the life cycle of the fungi have been discussed previously by the writer which may be considered in this connection.* The incipient ascus and incipient basidium are homologous structures and really represent the zygote in general. The basidium is the more specialized structure. This does not mean, however, that the basidium is a transformed ascus, or that it is to be derived from an ascus. Both structures have probably been derived from a simpler condition which would not properly be called either an ascus or a basidium. The septation of the basidium has taken place independently in several lines of Teliosporæ and Basidiomycetæ. Such parallel developments occur very commonly in diverse groups of higher plants and are not to be interpreted as indicating direct relationships unless the other morphological and physiological characteristics are in agreement.

The lower groups of the various series are mostly hermaphroditic (homothallic) and this condition may continue to a

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*SCHAFFNER, JOHN H. Principles of Plant Taxonomy, III. Ohio Jour. of Sci. *26:* 294–310. 1926.—Extraordinary Sexual Phenomena in Plants. Bull. Torr. Bot. Club, *54:* 619–629. 1927.

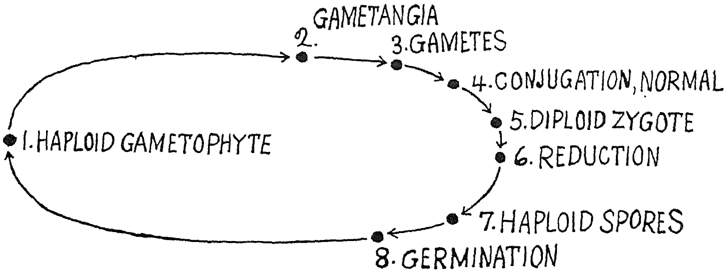

FIG.I.

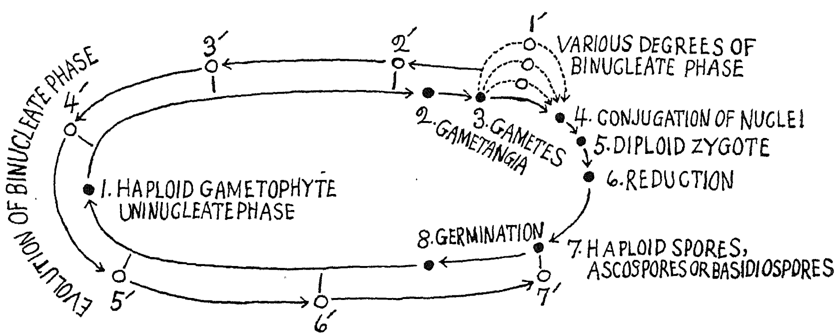

FIG.II.

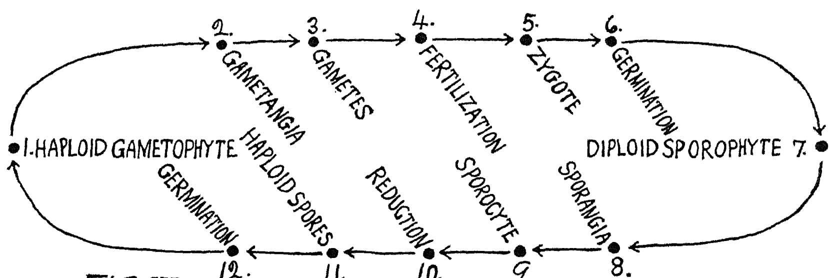

FIG.III.

EXPLANATION OF FIGS. 1, 2 AND 3.

FIG. 1. The normal simple haploid sexual life cycle.

FIG. 2. Diagrammatic representation of the evolution of a conjugate phase by modification of the simple haploid sexual life cycle of the lower fungi.

FIG. 3. The typical antithetic alternation of generations cycle which shows that there is no real alternation of generations of any kind in the fungi.

very high stage or even to the highest, as is also the case with bisporangiate flowers in the Anthophyta. As the series evolve, they usually develop species with unisexual individuals, female (+) and male (−), or heterothallism. The peculiar evolution of the binucleate phase in the highest species makes heterothallism, in the ordinary sense, impossible, since the plus (+) and minus (−) conditions are manifest only in the conjugate nuclei, and the synaptic chromosome mates. In the extreme species the entire mycelium is binucleate and the plus (+) and minus (−) states are in the inside of every cell. In addition to the remarkable development of the incomplete primary sexual states there also appears to be an evolution, in some groups, of decided physiological compatibilities and incompatibilities between various chromosome combinations, so that the ability to conjugate may involve more than the mere fact of plus and minus strains. These phenomena are comparable to the numerous physiological strains which involve the resistance and susceptibility of host plants, as in certain smuts. There have been various fantastic interpretations of the phenomena, but it is evident that the diverse types of mycelia produced with consequent incompatibilities of sex reaction do not mean that the Basidiomycetæ have an indefinite number of "sexes" but rather that the same kind of physiological conditions arise, because of the presence of specific chromosomes in the given nuclei, as those which interfere with the conjugation of sperms and eggs of diverse species of plants and animals.

The life cycle of an ordinary green alga or of a lower fungus is shown in figure 1. This, as stated, is the simple haploid sexual cycle. *Eremascus fertilis* has such a cycle except that the four haploid nuclei resulting from reduction are increased to eight by the addition of a vegetative division, giving eight ascospores instead of four which is the more common number following a reduction division. In *Coleochaete* the divisions are also multiplied after reduction. *Eremascus albus* has the same cycle and apparently the Phycomycetæ in general also. In figure 2 this simple haploid sexual cycle is indicated by the stages marked 1-2-3-4-5-6-7-8. When one passes from the Phycomycetæ to the lower Ascomycetæ, a very remarkable condition becomes evident through the intercalation of a binucleate phase between the cytoplasmic conjugation of the walled gametes and the final conjugation of the male and female nuclei to form the zygote. The first evidence of such a con-

dition evolving is the long delay in the fusion of the paired nuclei after they lie together in the fusion cytoplasm. This condition is present in some Zygomycetæ and in *Endogone lactiflua* where nuclear fusion is apparently not accomplished until the time of germination of the zygote (See Fig. 2=7-8-1-2-3-1′-4-5-6). In *Endogone pisiformis* fusion is said to occur shortly after copulation of the sexual branches. (See Figs. 1 or 2=7-8-1′-2-3-4-5-6). Some Oomycetæ also appear to have delayed nuclear fusion.

Now this condition of a partial attractive and interactive property of gametes, which for the time being falls short of complete nuclear fusion, the writer has called the incomplete or partial primary sexual state. Such states develop in the gametes of certain species of *Oedogonium* and *Bulbochaete*, where, although the original sperms (androspores) are attracted, no fusion of cells takes place for the time being but the androspores develop into dwarf males.

To gain a correct understanding of the peculiarities of sexual expression of the higher fungi, it is necessary also to take into account the various sexual states which may be present and their influence on the behaviour of the protoplast. The sexual states evident are: (1) Neutral state; (2) male and female secondary sexual states, which influence hereditary expression but do not induce attraction and fusion; (3) incomplete male and female primary sexual states, which induce attraction and in the fungi copulation of the cells involved but not a fusion of the nuclei, the nuclei nevertheless exerting an influence on each other so that they act harmoneously; and (5) complete male and female primary sexual states, which induce not only attraction but complete fusion of the nuclei, resulting in the organization of a unitary diploid nucleus; and at a later stage through the individual sexualization of the chromosomes, during the reduction division, giving rise to pairing and temporary fusion of the synaptic chromosome mates.

Now as stated above the delay of the fusion process in some of the lower fungi indicates a delay in the complete primary sexualization of the fusion nuclei. This delay turus out to be the initial stage of a remarkable orthogenetic evolutionary series; for the next step is the intercalation of vegetative divisions in the pair of conjugate nuclei, giving rise to the conjugate vegetative phase of the life cycle. In the lowest stages of this evolutionary movement, only a few divisions

take place, giving rise to small binucleate ascogenous hyphæ, on which the incipient asci are developed, in which, with complete primary sexualization of the conjugate nuclei, the diploid zygote nucleus is produced. This condition is present in such low Ascomycetæ as *Pyronema*, *Phyllactinia corylea*, etc., where the sexual cells or organs are slightly dimorphic. This dimorphism is due to a slight evolution of secondary sexual states which come to expression in the cells involved. After the copulation of the conjugate cells, the pair of conjugate nuclei undergo conjugate divisions in the small ascogenous hyphæ. The conjugate phase is soon ended by the formation of the hook-shaped processes at the tips of the binucleate hyphæ. This hook-shaped process must be regarded as a result of secondary sexualization of the cell concerned. The influence surrounding the male conjugate nucleus having its effect, at this stage, on the surrounding protoplasm while the cytoplasmic field surrounding the female conjugate nucleus is influenced in a different way. This differential secondary sexual condition is more marked in the higher Basidiomycetæ and is responsible for the development of clamp connections which are to be compared to the dimorphic development of the pair of gametangia in such algæ as *Vaucheria sessilis* and more especially with the end to end conjugation apparatus developed in some species of *Spirogyra*. Such similarity of morphological expression is to be looked upon as parallelism just as there are numerous parallel developments from isogamy to heterogamy or the evolution of secondary sexual states beyond the gametangia.

Not only is there an orthogenetic evolutionary advancement in the conjugate phase but there soon appears a characteristic movement, into earlier stages of the ontogeny, of the initiation of the incomplete primary sexual states or the time of determination of the conjugate phase. Thus the original conjugating cells or gametangia disappear since the secondary sexual states which arise in the new vegetative conjugating cells are apparently not intense enough in many cases to produce such dimorphism although in the higher Basidomycetæ some dimorphism does appear in connection with the development of clamp connections.

In some of the higher Ascomycetæ, as in *Humaria rutilans* and *Helvella*, the time of development of the incomplete primary sexualization is shifted backward in the ontogeny so that conjugation of the two cells takes place in the hyphæ of the hypo-

thecium. The life cycle is then approximately represented by Fig. 2=7-8-1-3′-2′-1′-4-5-6. These plants may, of course, have been in an isogamous condition when the conjugate phase began to evolve and then never got beyond this condition.

In the basidiomycetous series the development of the conjugate phase has gone farther as one would expect, from their more advanced condition in general structure and function. In the common rust, *Puccinia graminis* the uninucleate phase is developed on the barberry and ends with the aeciospores. The nature of the sexual conditions is not yet entirely cleared up but the plus and minus sexualization seems to be accomplished in contiguous cells in the base of the aecium. The nature of the pycnium is obscure, but it is not probable that it ever had anything to do directly with an antheridium phylogenetically even though it might be shown to develop male states at present. Much investigation remains to be done on the rusts before their variously complicated life cycles can be properly homologized. There are probably both homothallic and heterothallic primary mycelia present. In the smuts there is sometimes a short uninucleate phase, the binucleate phase being originated through the conjugation of sprout cells which are vegetative descendants of the basidiospores. The life cycle would then be according to the scheme of Fig 2=7-8-6′-5′-4′-3′-2′-1′-4-5-6. In the Tilletiales as in *Tilletia tritici*, the movement has proceeded further and the incomplete primary sexualization takes place in the basidiospores which then promptly conjugate and thus initiate the binucleate phase (Fig. 2=7-7′-6′-5′-4′-3′-2′-1′-4-5-6). In *Ustilago nuda* the movement has gone one step further. The four cells of the basidium (promycelium) which really represent four reduction spores or undifferentiated basidiospores develop the incomplete primary sexual states and thus initiate the binucleate phase. Now the fact that these smuts have evolved the binucleate phase to the limit is not to be taken as a criterion for placing them at the top of the taxonomic series of basidiomycetous forms. They are at the top of the conjugate series just as cycads have advanced to the extreme, diecious condition while sunflowers still have bisporangiate flowers. This condition does not place sunflowers below cycads. The general level of a species or group must be judged by the combined levels of all the evolutionary movements present.

Apparently some of the Basidiomycetæ still have a short uninucleate phase at the beginning of their life cycle. Their

cycle will then be represented by Fig. 2=7-8-6′ or 5′-4′-3′-2′-1′-4-5-6. Such a condition is apparently present in *Collybia conigena*, *Coprinus fimetarius*, etc. In species of this type cenocytic divisions may sometimes be present at first but these cenocytic developments have no direct bearing on the evolution of the conjugate phase.

In *Corticium* and apparently in many Gasteromycetæ the mature basidiospores are binucleate and subsequent divisions are of the conjugate type. The entire mycelium is therefore, binucleate. In *Secotium* according to Cunningham, each basidiospore receives one of the four reduction nuclei and the spores become binucleate promptly by division. On germination a germ tube is produced which branches abundantly, forming a septate mycelium and all the cells are binucleate. Thus the incomplete plus and minus primary sexualization is accomplished at the very beginning in two vegetative sister nuclei and conjugation of walled cells, or copulation, is entirely eliminated. There is also no more possibility for the development of a heterothallic mycellium. The evolutionary movement of incomplete primary sexualization has proceeded to the very limit. In *Secotium* the life cycle is thus as in Fig. 2=7-7′-6′-5′-4′-3′-2′-1′-4-5-6. Apparently the life cycles of *Lycoperdon excipuliforme* and of *Cyathus*, as reported, are quite similar.

The condition in *Secotium* is only the extreme vestige of the homothallic condition. In some Basidiomycetæ heterothallic conditions are present. The sexual states are determined in the initial nucleus of the basidiospores through functional states which to some extent may coincide with the presence of differential chromosomes distributed in the reduction division. In addition there may be combinations of physiological races or physiological states depending on individual chromosomes which may give compatible and incompatible reactions in connection with the sexual states developed, as discussed above. Referring only to the development of sexual states in relation to differential chromosomes, the conjugation of basidiospores, when such takes place, might be between homothallic pairs (homothallic condition) or between heterothallic pairs (heterothallic condition). If copulation of walled cells is eliminated, the two nuclei which come to be included in the basidiospore may also be homomorphic (homothallic condition—*Secotium*) or they might possibly also be heteromorphic and thus the vestige of a heterothallic condition.

The development of numerous reaction systems is not necessarily ascribed to a complexity of hereditary units shifted in the reduction division. There may be physiological differentiation giving peculiar sexual reactions and degrees of sexual compatibility and incompatibility, just as we have bacteria with intensified or attentuated virulence, depending apparently on the environmental conditions in which the organism is growing. Or as the two dichotomous buds of a Lycopodium, although having exactly the same hereditary constitution, react differently, the one growing against the force of gravity and the other at right angles to it. Or as in the sexual incompatibility developed in many flowering plants, where the differentation processes going on in certain types of hereditary constitutions result in complete self-sterility, while compatibility is shown with another individual.

The clamp connections are to be interpreted as due to secondary sexual states arising in the respective fields of influence of the plus (+) and minus (−) conjugate nuclei, at the time of each division, thus giving dimorphic expressions in cells and parts of cells comparable to the general development of sexual dimorphism in gametangia and the vegetative tissues beyond the gametangia. In this sense clamp connections can be compared directly with the hook-shaped structures in the Ascomycetæ. They do not necessarily imply any close derivation of the Basidiomycetæ from the Ascomycetæ, althought there can be no question but that Ascomycetæ and Basidiomycetæ are a monophyletic group of two more or less parallel series and that these in turn constitute a monophyletic group together with the Phycomycetæ, but not derived directly from them.

The orthogenetic evolutionary movement shown in the point of determination of the incomplete primary sexual states duplicates in a remarkable manner similar orthogenetic evolutionary movements in the time of secondary sex determination in the groups of sexual algæ, in the gametophytes of the Metathallophyta, and in the sporophytes of the heterosporous plants. In each of these series the evolution continues in a progression through the ontogeny of the individual, from determination at the end of the ontogeny to determination at the very beginning of the ontogeny when the extreme forms are reached. Such processes and relationships must be fully understood before correct phyletic taxonomies can be established.

SUPPLEMENT TO CATALOGUE OF TYPE FOSSILS IN THE GEOLOGICAL MUSEUM AT THE OHIO STATE UNIVERSITY.

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In 1924 a catalogue of the type fossils contained in the Geological Museum at the Ohio State University was published.* Since that date the collections have been increased by the addition of 106 types, and it now seems advisable to bring out this supplement to the catalogue of 1924. The plan of the supplement is the same as for the catalogue, both being patterned after the catalogue compiled by Dr. Charles Schuchert for the fossil invertebrates in the United States National Museum.†

For each entry the following information is given: (1) accession number; (2) name of species; (3) kind of type and number of specimens included in the entry; (4) formation; (5) locality; (6) author and place of publication. If the species name has been changed from that under which it was originally described, it is listed in the catalogue under both the original and the present names, with suitable cross references. Under the original name is listed the reference or references to the original description, and the cross reference is indicated by "=" the name under which the species is now known. Under the present name is listed the reference to the publication in which the change of name was made, and the cross reference is indicated by "*see*" the name under which the species was originally described. In the case where a type specimen has been described or figured under two or more names antedating the present name, a cross reference between these names is indicated by "*same as*" the other now discarded name. A few cases of this sort are listed in the original catalogue. If the generic name now used is not the same as that under which the species was originally described, the author's name is placed in parenthesis.

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*Morningstar, Helen. Ohio Jour. Sci., Vol. XXIV, No. 1, pp. 31-64, 1924.
†Schuchert, Charles. U. S. Nat. Mus., Bull. 53, Pt. 1, 1905.

Of the 106 types listed in this supplement 45 are primary or basic types, and 61 are secondary or supplementary types. With the exception of two or three specimens, all this material is from the Ohio rock formations. Some entries are included which were listed in the original catalogue as *chirotypes*. Descriptions and illustrations of these species have now been published, and the proper terms for the various types are here recorded.

The terms used descriptive of the various kinds of types are the same as those used in the catalogue of 1924. The definitions of these terms are as follows:

PRIMARY TYPES.

Holotype.—A single specimen selected from the original material on which a new species is based.

Paratype.—A specimen selected in addition to the holotype which is used in preparing the original description of a new species. A species may have, therefore, both holotype and one or more paratypes.

Cotypes.—Two or more specimens used in describing and figuring a new species where no holotype has been selected.

Chirotype.—A term applied to material described in the manuscript form. After the manuscript has been published the chirotype will become either a holotype, paratype, etc.

SECONDARY TYPES.

Plesiotype.—A specimen which was not used in the original description of a new species, but which is used for a subsequent description or figure of it.

ARTIFICIAL MODLES.

Plastotype.—An artificial cast or model made directly from a primary type is called a plastotype.

FIGURED SPECIMENS.

This includes specimens which have been described and figured but to which no specific name has been assigned. They cannot be classed as real types, and such entries are marked *figured*.

MARKING OF TYPES.

To distinguish primary types in the Geological Museum at Ohio State University small red stars are glued to the specimens. For the supplementary types green stars are used. The label is also starred and on it is recorded the kind of type and the reference to the description.

The total number of entries included in the catalogue of 1924 and the present supplement is 381, 15 of which are duplicate entries. Of these there are 80 holotypes, 21 paratypes, 49 cotypes, 179 plesiotypes, 14 chirotypes, 3 plastotypes and 20 figured specimens.

ALPHABETICAL LIST.

16285. *Acanthoclema sulcatum* Hall and Simpson. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 31, Pl. II, Figs. 13, 14.

16229. *Ambocoelia umbonata* (Conrad). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 49.

15330. *Ancylopus ortoni* Carman. Holotype.
Monongahela (Penn.). New Straitsville, Ohio.
CARMAN. Bull. Geol. Soc. Amer., Vol. XXXVIII, 1927, pp. 391–395, Pl. XIII.

15329. *Anomoeichnus ohioensis* Carman. Holotype.
Middle Kitanning, Allegheny (Penn.). New Straitsville, Ohio.
CARMAN. Bull. Geol. Soc. Amer., Vol. XXXVIII, 1927, pp. 388–391, Pl. XII.

16281. *Arthracantha carpenteri* (Hinde). Plesiotypes (3).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 22, Pl. I, Figs. 9–11.

16511. *Atrypa reticularis* (Linnaeus). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 42, Pl. IV, Fig. 1.

16512. *Athyris vittata* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 49, Pl. V, Fig. 1.

16270. *Aulopora serpens* Goldfuss (?). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 19, Pl. I, Fig. 4.

16553. *Baropus hainesi* Carman. Holotype.
16554. *Baropus hainesi* Carman. Paratype.
Monongahela (Penn.). Hackney, Morgan Co., Ohio.
CARMAN. Bull. Geol. Soc. Amer., Vol. XXXVIII, 1927, pp. 385–388, Pl. XI.

16965. *Bellephon hyaline* Hall. Plesiotype.
Columbus limestone (chert zone) (Dev.). Dublin, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, pp. 190–191, Pl. XVII, Figs. 3, 4.

16286. *Botryllopora socialis* Nicholson. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
HALL AND SIMPSON. Pal. N. Y., Vol. VI, 1887, p. 282, Pl. LXIV, Fig. 3.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 28, Pl. II, Figs. 5, 6.

16537. *Bythocypris indianensis* Ulrich. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 58, Pl. I, Fig. 13.

16513. *Camarotoechia prolifica* Hall (?). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 41, Pl. III, Fig. 24.

16271. *Ceratopora flabellata* Greene. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 20, Pl. I, Fig. 5.

16272. *Ceratopora jacksoni* Grabau. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 20, Pl. I, Fig. 6.

16505. *Chonetes coronatus* (Conrad). Plesiotypes (3).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 37, Pl. III, Figs. 13–15.

16259. *Chonetes fragilis* Stewart. Cotypes (4).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 38–39, Pl. III, Figs. 16–19.

16300. *Craniella hamiltonæ* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 35, Pl. III, Fig. 8.

16523. *Crinoid stems.* Figured (4).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 25, Pl. I, Figs. 12–15.

16507. *Cyrtina hamiltonensis* Hall. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 43, Pl. III, Figs. 27, 28.

5887. *Cyrtoceras hertzeri* Hall and Whitfield. Holotype.
Niagaran (Sil.). Cedarville, Greene Co., Ohio.
HALL AND WHITFIELD. Pal. Ohio, Vol. II, 1875, p. 150, Pl. VIII, Figs. 7, 8.
=*Hexameroceras hertzeri.*

16273. *Cystiphyllum vesiculosum* Goldfuss. Plesiotypes (4).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 18.

16287. *Cystodictya incisurata* (Hall). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 33, Pl. III, Figs. 5, 6.

16265. *Cytherella (?) bispinulatus* Stewart. Cotypes (3).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 60, Pl. V, Figs. 18, 19.

16515. *Diaphorostoma lineatum* (Conrad). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 56, Pl. V, Fig. 11.

3082. *Diestoceras eos* (Hall and Whitfield). Holotype.
Richmond (Ord.). Near Dayton, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XX, 1924, p. 265, Pl. III, Fig. 5.
See *Gomphoceras eos.*

16963. *Dipterus eastmani* Stauffer. Holotype.
Columbus limestone (Dev.). Whitehouse, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 196, Pl. XVII, Figs. 14–17.

1876. *Elrodoceras (?) carmani* Foerste. Holotype.
Niagaran (Sil.). Cedarville, Greene Co., Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIII, 1928, p. 261, Pl. LXXI, Fig. 1.

16531. *Favosites nitella* Winchell. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 52, Pl. I, Fig. 1.

16289. *Fistulipora vesiculata* (Hall and Simpson). Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 28, Pl. II, Figs. 3, 4.

3082. *Gomphoceras eos* Hall and Whitfield. Holotype.
Richmond (Ord.). Near Dayton, Ohio.
HALL AND WHITFIELD. Pal. Ohio, Vol. II, 1875, p. 100, Pl. III, Fig. 5.
=*Diestoceras eos.*

7304. *Graftonoceras graftenense* (Meek and Worthen). Plesiotype.
Niagaran (Sil.). Rising Sun, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXI, 1925, p. 59, Pl. XII, Figs. 3A, B.

3404. *Graftonoceras ortoni* (Meek). Holotype.
Niagaran (Sil.). Greenville, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXI, 1925, p. 61, Pl. XII, Figs. 5A, B.
See *Lituites (?) ortoni* Meek.

7057. *Graftonoceras ortoni* (Meek). Plesiotype.
Niagaran (Sil.). Wilmington, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXI, 1925, p. 61, Pl. XII, Figs. 4A–E.

16522. *Grammysia bisulcata* (Conrad). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 50, Pl. V, Fig. 2.

16290. *Hederella canadensis* (Nicholson). Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 25, Pl. I, Figs. 16, 17.

16292. *Hederella cirrhosa* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 26, Pl. I, Fig. 18.

16293. *Hederella magna* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 26, Pl. I, Fig. 19.

16274. *Heliophyllum halli* Milne-Edwards and Haime. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 19, Pl. I, Fig. 3.

5887. *Hexameroceras hertzeri* (Hall and Whitfield). Holotype.
Niagaran (Sil.). Cedarville, Greene Co., Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 375, Pl. XLIX, Figs. 3A, B.
See *Cyrtoceras hertzeri*.

16768. *Intrapora (?) irregularis* Stewart. Cotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 33, Pl. III, Figs. 2–4.

16538. *Isochilina scapha* Stewart. Holotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 57, Pl. I, Figs. 11, 12.

14802. *Kionoceras* sp. Figured.
(3431A). Niagaran (Sil.). Yellow Springs, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIII, 1928, p. 290, Pl. LXV, Fig. 3.

14803. *Kionoceras* sp. Figured.
(3431B). Niagaran (Sil.). Yellow Springs, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIII, 1928, p. 290, Pl. LXII, Fig. 6.

3160. *Kionoceras strix* (Hall and Whitfield). Plesiotype.
Niagaran (Sil.). Cedarville, Greene Co., Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIII, 1928, p. 293, Pl. LXVII, Fig. 1.

16533. *Leiorhynchus kelloggi* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 54, Pl. I, Figs. 3, 4.

16260. *Leiorhynchus lucasi* Stewart. Holotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 42, Pl. III, Figs. 25, 26.

16536. *Leperditia* (?) *subrotunda* (?) Ulrich. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 57, Pl. I, Fig. 10.

3404. *Lituites* (?) *ortoni* Meek. Holotype.
Niagaran (Sil.). Greenville, Ohio.
MEEK. Pal. Ohio, Vol. I, 1873, p. 186, Pl. XV, Fig. 4.
(*Gyroceras ortoni* at end of description.)

= *Graftonoceras ortoni*.

16139. *Modiomorpha concentrica* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 52, Pl. V, Fig. 4.

16514. *Modiomorpha mytiloides* (Conrad) (?). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 53, Pl. V, Fig. 5.

16267. *Monotrypella ohioensis* Stewart. Cotypes (4).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 29–30, Pl. II, Figs. 7–10.

16294. *Monotrypella* sp. Figured.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 30, Pl. III, Fig. 1.

16967. *Murchisonia eversolensis* Stauffer. Holotype.
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 191, Pl. XVI, Fig. 13.

16968. *Murchisonia intermedia* Stauffer. Holotype.
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, pp. 191–192, Pl. XVI, Fig. 91.

16969. *Murchisonia quadricarinata* Stauffer. Cotypes (2).
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 192, Pl. XVII, Figs. 10, 11.

3405. *Ophidioceras wilmingtonense* Foerste. Holotype.
Niagaran (Sil.). Yellow Springs, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXI, 1925, p. 66, Pl. XXIV, Figs. 4A, B.

3423A. *Orthoceras crebescens* Hall and Whitfield. Plesiotype.
Niagaran (Sil.). Cedarville, Greene Co., Ohio.
HALL AND WHITFIELD. Pal. Ohio, Vol. II, 1875, p. 148, Pl. IX, Fig. 2.
= *Orthoceras whitfieldi.*

3423A. *Orthoceras whitfieldi* Foerste. Paratype.
Niagaran (Sil.). Cedarville, Greene Co., Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIII, 1928, p. 243, Pl. L, Fig. 2.
See *Orthoceras crebescens.*

17114. *Orthophragmina meroensis* W. Berry. Cotypes (3).
Samon cgl. (Eocene). Cal Mero, Peru.
W. BERRY. Jour. Wash. Acad. Sci., Vol. XX, 1930.

16964. *Palaeoneilo (?) sanduskiensis* Stauffer. Holotype.
Delaware limestone (Dev.). Sandusky, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 190, Pl. XVI, Figs. 7, 8.

16295. *Paleschara (?)* sp. Figured.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 34, Pl. III, Fig. 7.

16266. *Phacops rana* var. *milleri* Stewart. Cotypes (3).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 58–60, Pl. V, Figs. 14–17.

16502. *Pholidostrophia iowaensis* (Owen). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 36, Pl. III, Fig. 12.

3145.

3148. *Phragmoceras augustum* (Newell). Plesiotypes (3).

3149. Niagaran (Sil.). Marion, Indiana.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 330.

7302A. *Phragmoceras auroraense* Foerste. Holotype.

7302B. *Phragmoceras auroraense* Foerste. Paratype.
Niagaran (Sil.). Rising Sun, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 333, Pl. LIII, Figs. 1A, B; 2A, B.

14809B. *Phragmoceras auroraense* Foerste. Paratype.

(9442B). Niagaran (Sil.). Bowling Green, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 333, Pl. LIII, Fig. 3.

14912. *Phragmoceras carmani* Foerste. Holotype.
Niagaran (Sil.). Greene Co., Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV. 1929, p. 337, Pl. LV, Fig. 1.

9442A. *Phragmoceras* cf. *colliciare* Foerste. Paratype.
Niagaran (Sil.). Bowling Green, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 339, Pl. LII, Figs. 3A, B.

3413. *Phragmoceras ellipticum* Hall and Whitfield. Holotype.
Niagaran (Sil.). Highland Co., Ohio.
HALL AND WHITFIELD. Pal. Ohio, Vol. II, 1875, p. 152, Pl. 8, Fig. 11.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 343, Pl. L, Fig. 4.

3414. *Phragmoceras hillsborense* Foerste. Holotype.
Niagaran (Sil.). Highland Co., Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 345, Pl. LI, Figs. 1A, B.

5889. *Phragmoceras parvum* Hall and Whitfield. Holotype.
Niagaran (Sil.). Cedarville, Ohio.
HALL AND WHITFIELD. Pal. Ohio, Vol. II, 1875, p. 151, Pl. VIII, Fig. 10.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 351, Pl. LV, Fig. 2.

9441A. *Phragmoceras wilmingtonense* Foerste. Paratype.
Niagaran (Sil.). Bowling Green, Ohio.
FOERSTE. Jour. Sci. Lab., Denison Univ., Vol. XXIV, 1929, p. 359, Pl. LI, Figs. 2A, B.

16974. *Platyceras blatcheyi* Kindle. Plesiotype.
Columbus limestone (zone H) (Dev.). Dublin, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 192, Pl. XVI, Figs. 11, 12.

16144. *Platyceras bucculentum* Hall. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 54, Pl. V, Figs. 6, 7.

16516. *Platyceras carinatum* Hall. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 55, Pl. V, Figs. 8, 9.

16517. *Platyceras rarispinum* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 56, Pl. V, Fig. 10.

16973. *Platyostoma subglobosa* Stauffer. Holotype.
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 192, Pl. XVI, Fig. 6.

16970. *Pleurotomaria cancellata* Stauffer. Cotypes (2).
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 193, Pl. XVII, Figs. 1, 2.

16971. *Pleurotomaria dublinensis* Stauffer. Cotypes (3).
Columbus limestone (chert zone) (Dev.). Dublin, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 193, Pl. XVII, Figs. 7–9.

16972. *Pleurotomaria sciotensis* Stauffer. Cotypes (2).
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 194, Pl. XVII, Figs. 5, 6.

16544. *Productella spinulicosta* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 39.

16976. *Proetus welleri* Stauffer. Holotype.
Columbus limestone (Dev.). South of Venice, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 195, Pl. XVII, Figs. 12, 13.

16140. *Pterinea flabellum* Conrad. Plesiotypes (4).
Silica shale (Dev.). Silica, Ohio.
HALL. Pal. N. Y. Vol., V, Pt. I, Lamellibranchiata, 1884, p. 93, Pl. XIV, Fig. 3.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 51, Pl. V, Fig. 3.

16296. *Reptaria stolonifera* Rolle. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 27, Pl. II, Figs. 1, 2.

16297. *Reteporina striata* Hall. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 30, Pl. II, Figs. 11, 12.

16503. *Rhipidomella vanuxemi* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 40, Pl. III, Fig. 20.

16501. *Schizophoria striatula* (Schlotheim). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 40, Pl. III, Fig. 21.

16261. *Schizophoria striatula* v. *parvum* Stewart. Holotype and Paratype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 40, Pl. III, Figs. 22, 23.

16510. *Spirifer audaculus* (Conrad). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 44, Pl. IV, Figs. 2, 3.

16263. *Spirifer bownockeri* Stewart. Cotypes (3).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 45–46, Pl. IV, Figs. 4–6.

16508. *Spirifer euryteines* Owen. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 46, Pl. IV, Figs. 7, 8.

16961. *Spirifer lucasensis* Stauffer. Cotypes (5).
Traverse formation (Dev.). Whitehouse, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, pp. 188-189, Pl. XVI, Figs. 1–5.

16262. *Spirifer mucronatus* v. *prolificum* Stewart. Cotypes (6).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 47–49, Pl. IV, Figs. 9–14.

16280. *Spirorbis arkonensis* Nicholson. Plesiotype.
Stropheodonta perplana (Conrad). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 21, Pl. III, Fig. 11.

16264. *Spirorbis planum* Stewart. Holotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 21–22, Pl. I, Figs. 7, 8.

16269. *Stictoporina granulifera* Stewart. Holotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 32, Pl. II, Figs. 17–19.

16975. *Straparollus corrugatus* Stauffer. Holotype.
Columbus limestone (chert zone) (Dev.). Eversole Run, Ohio.
STAUFFER. Geol. Surv. Ohio, Fourth Ser., Bull. 10, 1909, p. 194, Pl. XVI, Fig. 10.

16298. *Streblotrypa hamiltonensis* Nicholson. Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 31, Pl. II, Figs. 15, 16.

16299. *Stropheodonta demissa* (Conrad). Plesiotypes (2).
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 35, Pl. III, Figs. 9, 10.

16532. *Stropheodonta demissa* var. Figured.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 53, Pl. I, Fig. 2.

16280. *Stropheodonta perplana* (Conrad). Plesiotype.
Spirorbis arkonensis Nicholson. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 36, Pl. III. Fig. 11.

16519. *Styliolina fissurella* (Hall). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 57, Pl. V, Fig. 12.

16520. *Tentaculites bellulus* Hall (?). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 57, Pl. V, Fig. 13.

16534. *Terebratula mediocris* Stewart. Holotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 55, Pl. I, Figs. 5–7.

16535. *Tornoceras uniangularis* (Conrad). Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Ohio Jour. Sci., Vol. XXX, 1930, No. 1, p. 56, Pl. I, Figs. 8, 9.

17109. *Xiphias (?) drydeni* W. Berry. Holotype.
Calvert (?) (Miocene). Calvert Co., Maryland.
W. BERRY. Jour. Wash. Acad. Sci., Vol. XX, No. 3, Feb. 1930, p. 41, Figs. 1, 2.

16278. *Zaphrentis prolifica* Billings. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, pp. 16–17, Pl. I, Fig. 1.

16277. *Zaphrentis simplex* Hall. Plesiotype.
Silica shale (Dev.). Silica, Ohio.
STEWART. Geol. Surv. Ohio, Fourth Ser., Bull. 32, 1927, p. 17, Pl. I, Fig. 1.

THIRD LAYER OF AMOEBA VS. TRICHOCYSTS OF PARAMECIUM.*

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INTRODUCTION.

We are often asked by students and co-workers why amoebæ with no weapons of defense can capture and digest *Paramecium caudatum* and other protozoa when these organisms possess such weapons as trichocysts (Fig. 3).

We believe we can answer the above question from observations we have made. In these observations, which will be described in detail in the following pages, we have found that, when an Amoeba has succeeded in killing a Paramecium, the former organism was mature in practically every case. An immature amoeba was unsuccessful according to our observations, since the third layer was not thick enough to protect it from the trichocysts of the Paramecium. We feel the third layer is the essential structure used by the Amoeba in securing food and, therefore, we have described the characteristics of that layer in the following paragraphs.

THE THIRD LAYER.

That a third layer exists on an Amoeba was indicated by observations made by Butschli (2) in 1892 and by Blochmann (1) in 1894. Several years later Gruber (4) recognized the same structure and described it as a permanently differentiated layer composed of gelatinous substance. Schaeffer (12) in 1917 called the third layer one of protoplasm which moves faster than the forward advance of the Amoeba and later gave a very clear description of its movements as indicated by its ability to carry particles.

Jennings, (5) on the other hand, concluded from his observations that no third layer existed, but that particles clinging to the outside of the Amoeba were carried toward the anterior end by the ectoplasm.

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*We are indebted to Doctor H. O. Halvorson for many helpful criticisms in preparing this paper.

We are convinced, however, that a third layer does exist and that the age of the Amoeba determines the thickness of this layer. We are further convinced that the thickness of the third layer is an important factor in determining the kind of food secured by the Amoeba. In this connection, we noticed in our cultures that a very young Amoeba lives upon bacteria,

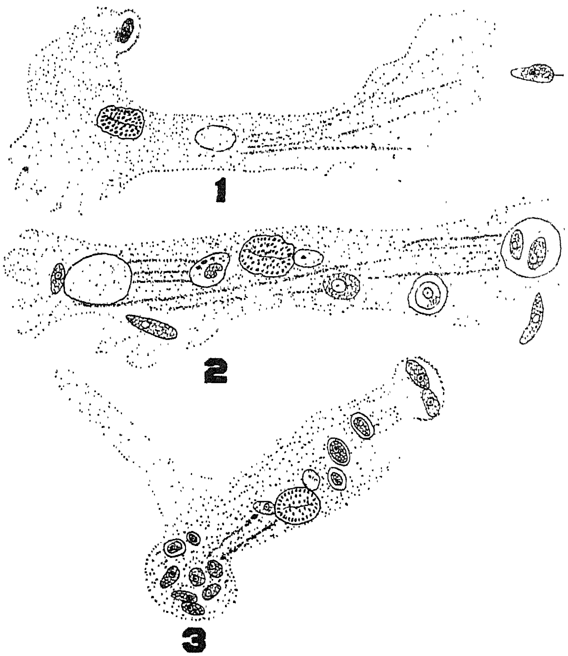

FIG. 1. Amoeba with its third layer surrounding a Chilomonas paramecium.
FIG. 2. Chilomonas paramecia with the third layer of an amoeba surrounding them forming food vacuoles.
FIG. 3. The third layer of an amoeba surrounding two Chilomonas paramecia at the extreme right. The third layer disappears as the food vacuoles approach the nucleus. At the posterior end of the amoeba there are numerous Chilomonas paramecia. These were caught when the amoeba was flowing in the direction opposite to the one shown in the diagram.

when older it chooses *Chilmonas paramecium* (Text Figs. 1, 2, 3), later paramecia is the principal diet, and finally Rotifers are selected.

According to our observations practically all conflicts between mature Amoeba and Paramecium were fought to the advantage of the former organism. On the other hand a young Amoeba, in such a battle, always lost. While working on the life cycle of *Amoeba proteus*, (Jones (6), we observed in

one of Dr. Kepner's cultures a conflict between a young Amoeba, a Paramecium and another protozoan, *Urotricha farcata.* In this skirmish, the Amoeba attacking the Paramecium, began to project pseudopodia almost immediately on either side of the Paramecium but before they had extended far, it put out another in the opposite direction as if to move away. In the meantime, *U. farcata* came up to the Paramecium and stopped, then it tried to move away but its efforts were feeble. The Paramecium by means of its trichocysts killed both the Amoeba and *U. farcata.* At this point the Paramecium was killed with osmic acid fumes and fixed as described below.* In the photograph (Fig. 1), the reader can see the trichocysts discharged into the Amoeba and *Urotricha* and that the latter is a little swollen in the direction of the Paramecium. It is of interest to note the Paramecium apparently discharged only those trichocysts which came in contact with the Amoeba and *Urotricha.*

Although, as previously stated, we feel that the age of the Amoeba and, therefore, the amount of third layer present is extremely important in determining the kind and size of food secured by the organisms, we have also noticed that even a mature Amoeba is not always successful in killing a Paramecium. Sometimes the latter is able to free itself without difficulty from an Amoeba. Such an escape, we are confident is due to the absence of a necessary amount of third layer on the surface of the Amoeba at the time the Paramecium is caught. When the Amoeba has caught several organisms, each of those animals takes with it to the interior of the Amoeba a certain amount of third layer, (Text Figs. 2, 3). As a result, if several organisms have previously been caught and, therefore, several food cups formed in the Amoeba, there naturally will be less of the third layer on the surface. Under such a condition the Amoeba is of course less able to hold its prey, and often the latter gets away. Kepner and Whitlock (10) show a good example of this in Plate III (Fig. 12). In this illustration it is evident that an Amoeba caught a euglena after several other organisms has previously been secured. The euglena escaped, a condition due, undoubtedly, to an insufficient amount of third layer on the surface of the Amoeba at the time the flagellate was caught.

*The organisms were killed with osmic acid fumes, fixed in Schaudinn solution (Saturated HgCl2 in 95 per cent alcohol plus acetic acid) and stained in Heidenhain's iron-alum-haematoxylin (short method).

The small amount of third layer present on the surface was needed by the Amoeba to protect the ectoplasm and endoplasm of its body from the lashing flagellum of the euglena.

There are no indications of the third layer possessing any power of digestion, since no signs of erosion occur until all the third layer has left the food vacuoles or has been digested by the enzymes in the endoplasm.

After protozoa have been caught and taken into the Amoeba, the food vacuole containing the imprisoned organisms passes towards the nucleus. During this passage the third layer, taken in the food vacuole with the organisms, gradually disappears and is entirely gone by the time the vacuole reaches the nucleus (Text Figs. 3). The contents of the food vacuole are then digested and the indigestible particles pass away from the nucleus and out of the Amoeba at the posterior end.

When an Amoeba catches protozoa at one end and then reverses its direction of flow, such as illustrated in Text figure 3, the organisms caught remain at the posterior end until the movements of the Amoeba cease or are reversed again.

TRICHOCYSTS.

Paramecium in defending themselves against Amoeba, project short stout rods called trichocysts. Although there is little definite information about these rods it is known that they lie within the ectoplasm. A few investigators are of the opinion that trichocysts are used chiefly for protection, others feel they must be weapons used for offense while still others hesitate to credit them with either function. Mast (11) supporting the theory that the Paramecium uses its trichocysts for protection, discusses the behavior of the organism when encountering its worst enemy, the *Didinium*. The latter attacks its prey by means of a peristome which can be discharged as an elongated tubler proboscis. If it succeeds in fixing this structure to a Paramecium it is usually able to suck much of its prisoner's body into its own. According to Mast (11), when the Paramecium is attacked by a *Didinium*, it discharges its trichocysts, which form a great tangled mass about the body of its enemy. This discharge of trichocysts, in the cases of the largest Paramecia forms such a dense mass that the *Didinium* is pushed free from the Paramecium and the latter thus escapes death.

Our observations coincide with those of Mast, but we have also noticed that the trichocysts are entirely liberated from the body of the Paramecium when it is attacked by a *Didinium* but are not liberated when it is attacked by other animals. Such a condition, we feel, must be due to a stimulus caused by an injection of material from the proboscis of the *Didinium*. Figures 1, 3, shows trichocysts discharged but still attached to the Paramecium.

A MATURE AMOEBA ENGULFS A PARAMECIUM WITH ITS THIRD LAYER.

When a Paramecium is not moving about but has its cilia in motion, currents are set up by the cilia which become swifter as they pass from the anterior to the posterior end of the animal. If an Amoeba is near enough the Paramecium to receive a stimulus from these currents, the first pseudopodium formed by the Amoeba will be pointed toward the posterior end of the Paramecium, since this is the source of greatest stimulus. As the Amoeba moves nearer the Paramecium, other pseudopodia of smaller size are formed. These are right and left of the first pseudopodium. When a pseudopodium touches the Paramecium the third layer of that pseudopodium immediately engulfs the Paramecium.

In catching a Paramecium or any other animal of similar structure, it is necessary for the third layer of the Amoeba to first surround or engulf the emprisoned organism. Naturally according to this method of securing food, it is necessary for the Amoeba to have plenty of third layer.

Kepner and Whitlock's (10) drawings, reproduced on Plate III (Figs. 9, 10, 11), describe the catching of a Paramecium by an Amoeba as follows: The amoeba was advancing in a general way toward the Paramecium along pseudopodia 1, 2 and 3. As it approached the ciliate, pseudopodia 1 and 2 widened and partly fused to form a large bi-lobed extremity, m-ml. When this extremity had nearly touched the Paramecium, it sent out a small psudopodium, beneath the prey, and b anterior to it (Fig. 10). When the pseudopodia, a and b came in contact with the detritus, y, they moved apart and become much stouter (Fig. 11). In the meantime a third pseudopodium, e, appeared projecting from between a and b over the dorsal side of the Paramecium, while a pocket was formed within the body

proper of the amoeba at the bases of these three pseudopodia. The Paramecium first jumped to position 2, Fig. 11. The excited Paramecium next backed into the pocket of the body proper, 3 and a, b, and e, closed in and surrounded it completely."

Our interpretations of the diagrams described above differ from those given by Kepner and Whitlock, since we bring into use the third layer. According to our interpretations the Paramecium was still, but its cilia were moving violently, judging by the amount of debris that was passing along the side and back of the posterior end of the Paramecium. The stimulus thus set up caused the Amoeba to put forth pseudopodium number 2 first, 3 next, then one, since this was the order of the stimulus as it was received by the Amoeba; notice, number 1 would touch the Paramecium about the center; 2 is off at the posterior end, while 3 would be useless in catching the Paramecium. The next in order, number 4, would be out of consideration. As 1 and 2 approached nearer the Paramecium, the third layer of either pseudopodia 1 and 2 or both would flow around and engulf the Paramecium. Figure 4, text figures 1 and 2, shows the third layer of an Amoeba surrounding *Chilomonas paramecium* in this same fashion.

The engulfing of a paramecium by the third layer may be due to the adhesive forces. The third layer having a strong affinity for the surface of a paramecium tends to flow over and around it. This same flow may cause a shifting of surface tension forces, which will account in part, at least, for the withdrawal of extended pseudopodia as in Plate III, Fig. 10. Part of the third layer having flowed around the Paramecium will tend to level out, due to surface tension forces, thus drawing the Paramecium into the cytoplasm of the Amoeba or, visa versa, the cytoplasm of Amoeba around the Paramecium. As a result, secondary pseudopodia flow up through the third layer and around the paramecium finally engulfing the organism along with some of the third layer as pictured by Kepner and Whitlock (10), Plate III, Fig. 11. These authors, in observing this condition, however, pictures the Amoeba surrounded by a layer of water instead of protoplasmic substance. According to our observations, third layer and not water surrounded the engulfed organism as we were able to stain the material, (Fig. 4, Text figures 1, 2, 3).

Kepner and Whitlock (10) state "that an Amoeba may react to a quiet paramecium in three ways; (1) by forming a pocket within its own body within which the ciliate will be driven (Figs. 9, 10, 11, 12), by sending encircling pseudopodia about the prey and then roofing over and flooring the enclosed space with ectoplasm before disturbing the prey, and (3) by closing in upon the Paramecium with the advancing tips of two pseudopodia until the prey is held fast in a grip of the pseudopodia ends. After the Paramecium is thus caught, it is very tightly closed in upon and constricted."

We have observed that the pseudopodia will only extend around the third layer. In other words, the pseudopodia will not encircle a living protozoan until the third layer has completely surrounded the prey.

We have also seen mature Amoeba catch *Chilomonas paramecium* in the manner described by Kepner and Whitlock (10) but in every instance observed in stained preparations, the third layer had surrounded the *Chilomonas paramecium* before the cup of the Amoeba began to close.

SUMMARY.

1. Paramecium can kill young amoeba with its trichocysts.
2. Mature amoeba has a thicker third layer than an immature one which protects the ectoplasm and endoplasm from the trichocysts of other protozoa.
3. Trichocysts are not thrown off from a paramecium when attacking amoeba and Urotrichia as described by Mast when *Didinium* attacks the paramecium.
4. Pseudopodia will not extend around an organism until the third layer has first surrounded it.
5. The organism caught by an amoeba is carried towards the nucleus, the third layer in the food vacuole disappears as digestion takes place.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Paramecium with its trichocysts discharged, killing a young amoeba and a Urotricha.

Fig. 2. *Amoeba proteus* showing the third layer surrounding the amoeba. The amoeba is filled with food vacuoles. Notice the two Chilomonas paramecia. The one at the posterior end shows signs of erosion, while the one at the large end shows no such change. The dark bodies, except the large one which is the nucleus, are food vacuoles in different degrees of digestion.

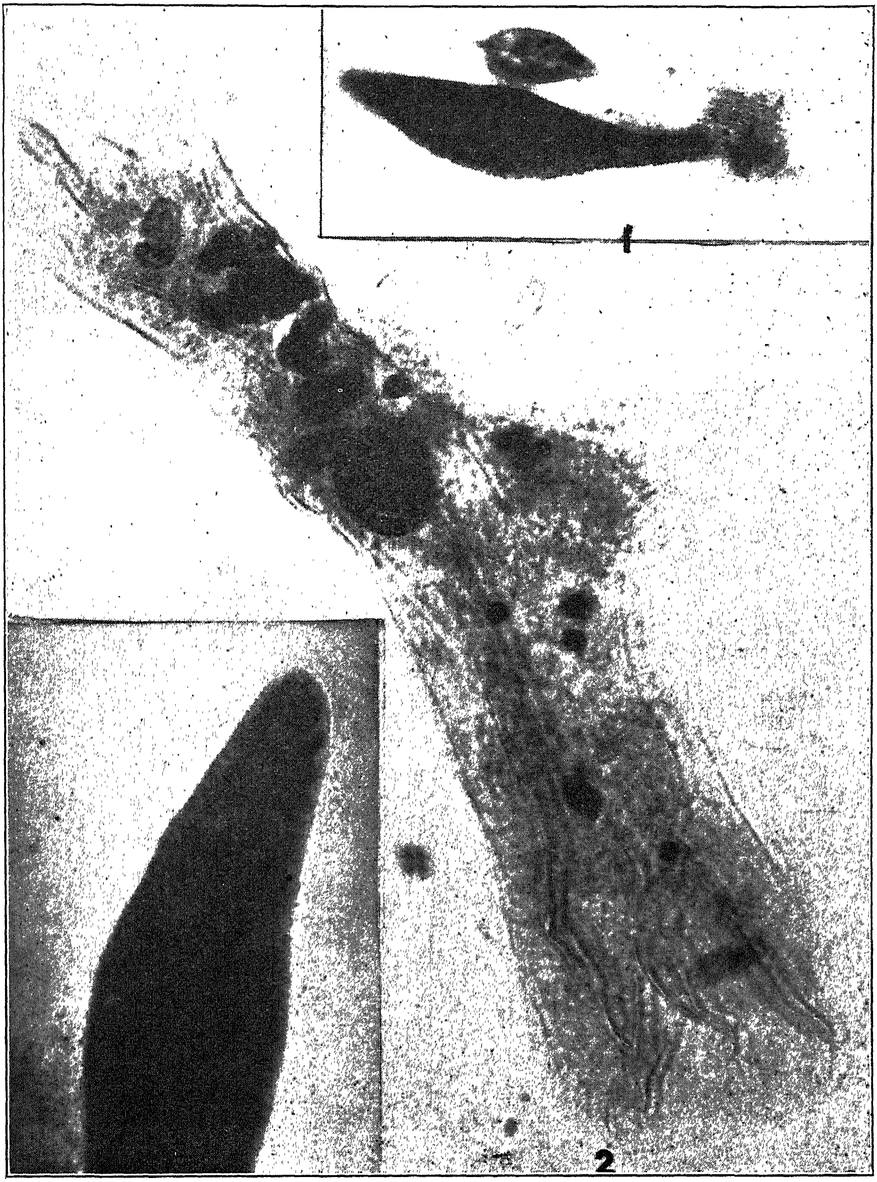
Fig. 3. Paramecium cordatum with its trichocysts extended; the capsules are stained black with iron heamatoxylin.

PLATE II.

Fig. 4. Amoeba catching active moving Chilomonas paramecia by surrounding them with the third layer on the arms while it is catching a chilomonas in a food cup at the larger end.

PLATE III.

Figs. 9, 10 and 11. Shows an amoeba catching a paramecium as explained by Kepner and Whitlock. (Reproduced by permission of Dr. Kepner.)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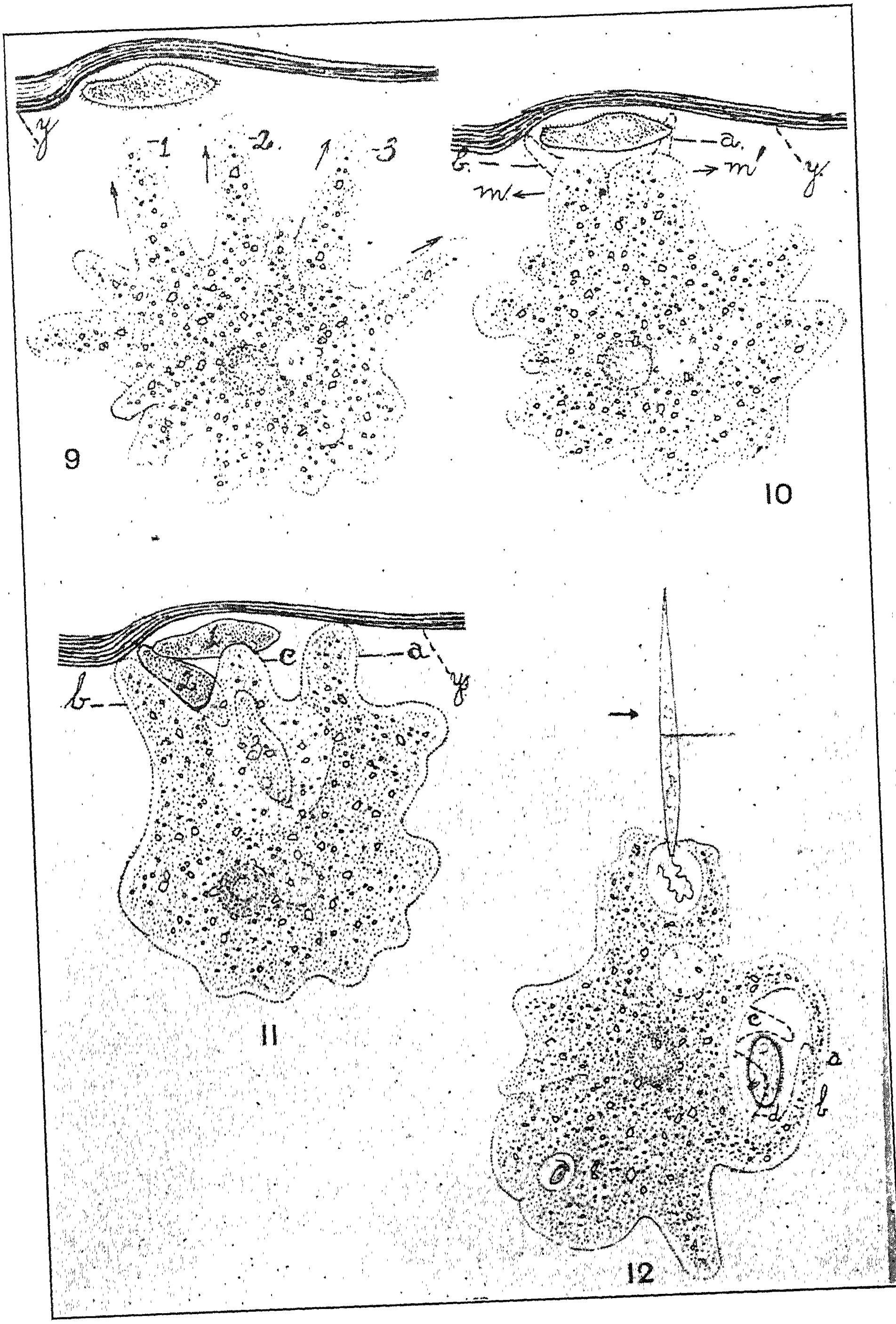
Amoeba vs. Trichocysts of Paramecium
Philip M. Jones



PLASMODIOPHORA LEWISII, NOV. SP.

PHILIP M. JONES,
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In the spring of 1926, I found mycetozoa living on some tomato and tobacco plants in the University of Chicago greenhouse. I picked up some of these organisms with a Barber pipette and transferred them to six 500 c.c. flasks containing 100 c.c. of serile Knop's solution. Bacteria were put in the flasks for the mycetozoa for food. Knop's solution was used for the organisms instead of wheat or hay infusion because th ph. in the former remains more constant.

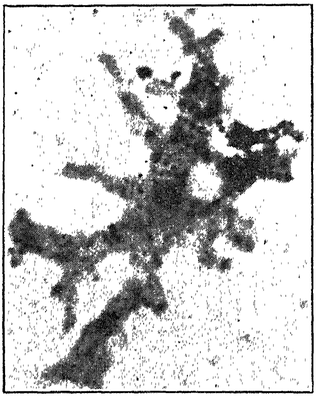

FIG. 1. Preplasmodium of *P. brassicæ* showing its nucleus and the karyosome lying against the nuclear membrane. The black dots filling the cytoplasm are oil globules. ×1000.

When first studying the mycetozoan, I noticed that it had but a single nucleus, which divided by promitosis, (Figs. 2, 3, 11). I also noticed that it moved by a rhythmic flow, which was quite different from the method employed by other mycetozoans. Though this method of movement resembled more that used by the myxomycetes, yet the contents did not flow through the vein-like structure which is so evident in the latter. Since the pseudopodia in this new organism were of typical myxopodia type, (Figs. 2, 3) the organism may be assumed to feed as others with pseudopodia of this kind.

In moving, one pseudopodium would contract with a rapid flowing movement into a lobe-like structure, (Figs. 2, 3). The contents of this lobe would then flow into another pseudopodium as if the lobe had been squeezed. The contraction of the pseudopodium into a lobe followed by the apparent squeezing of this lobe, which caused the contents to go elsewhere, gave the organism the rhythmic movement. The plasmodium in its extended form averaged 76 u. in length.

This new mycetozoan reminded me very much of the pre-plasmodium I have reported for *Plasmodiophora brassicæ*, (b) (Text Fig. 1). Oil globules, however, which were found in the latter, were missing in this organism. The method of movement also was very different from that found in *P. brassicæ.*

PRE-CYST.

In unfavorable conditions the whole plasmodium would round itself into a ball (Fig. 1). A thin wall was first secreted about the organism (pre-cyst) and then if conditions were again favorable, the plasmodium would flow out of the pre-cystic condition leaving the pre-cyst wall behind and move and feed as before, (Fig. 8). The pre-cyst averaged 20 u. in diameter. If, however, favorable conditions did not return after the pre-cyst was formed, another wall, much thicker than the first would be formed and a true cyst was the result, (Fig. 6). The cyst averaged 14 u. in diameter.

NUCLEUS.

The nucleus was a spherical structure, and appeared very small for the amount of cytoplasm. It had a karyosome which did not lie in the center of the nucleus but to one side, touching the nuclear membrane, (Fig. 10). During nuclear division this karyosome divided first, which the spindle occurring between the two polar masses, within the nuclear membrane, (Fig. 11). The organism then divided forming two new individuals, I have often found the plasmodium with two nuclei before the cytoplasm divided. Only twice have I found a plasmodium with four nuclei.

AMOEBA AND FLAGELLATE STAGES.

When favorable conditions such as food and temperature returned, the nucleus of the plasmodia cyst gave off chromidia

into the cytoplasm. Small flagellates were developed from these chromidia. The cyst and pre-cyst walls soon ruptured (Fig. 4), and the flagellates were liberated, (Fig. 5). These flagellates had a single flagellum, but showed no signs of conjugation. After swimming around in a dancing movement for a time these organisms developed pseudopodia at the posterior end. The pseudopodia were used in obtaining bacteria for food.

The flagellates later changed into amoebæ (Fig. 7). This change occurred under certain conditions as described in *P. tabaci* (a). In the amoeba stage the ectosarc could not be differentiated from the endosarc although the food material inside the organism might at first sight give one the impression that the two layers could be distinguished. I also noticed that the two cell layers could not be differentiated in the plasmodium stage.

If unfavorable conditions arose during the amoeba stage, the organism developed into a pre-cyst and cyst. Under normal conditions, however, the amoeba continued in this stage until a certain period of growth was reached and then was transformed into a pre-cyst. During this pre-cyst stage the nucleus gave off chromidia (Fig. 4), as was done in the cyst stage. I have not observed any gametes formed from these chromidia but judging from such an occurrence in *P. brassicæ* (b), *P. tabaci* (a), and *Amoeba proteus* (c), I firmly believe that gametes are produced following the pre-cyst stage in this organism. I also believe that the sexual stage takes place following the pre-cyst condition before the plasmodium is produced.

CLASSIFICATION.

SUB-PHYLUM—Sarcondia, Calkins.
  CLASS—Rhizopoda, Calkins.
    SUB-CLASS—Mycetozoa, Debary.
      ORDER—Phytomyxidia, Schroter.
        FAMILY—Plasmodiophoraceæ, Gaumann.
          GENUS—Plasmodiophora, Woronin.
            SPECIES—Lewisii.*

*Named for Doctor I. F. Lewis, of the University of Virginia.

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(a) **Jones, Philip M.** Structure and cultural history of a mycetozoan found in tobacco plants with mosaic-like symptoms. Bot. Gaz. LXXXI: 446–459. 1926.

(b) **Jones, Philip M.** Morphology and cultural history of P. brassicae. Archiv. f. Protestenkunde. Bd. 63, 213; 331–327. 1928.

(c) **Jones, Philip M.** Life cycle of Amoeba proteus with special reference to the sexual stage. Archiv. f. Protestenkunde. Bd. 63, 3: 322–332. 1928.

EXPLANATION OF PLATE I.

(All photographs are ×960.)

Fig. 1. Pre-cyst just before the wall is formed.

Figs. 2, 3. Two plasmodia which have just formed lobes. Each lobe was formed by a contraction of a single pseudopodium.

Fig. 4. Pre-cyst of mature amoeba. The nucleus is giving off chromidia.

Fig. 5. Flagellate Stage.

Fig. 6. Cyst of a plasmodium.

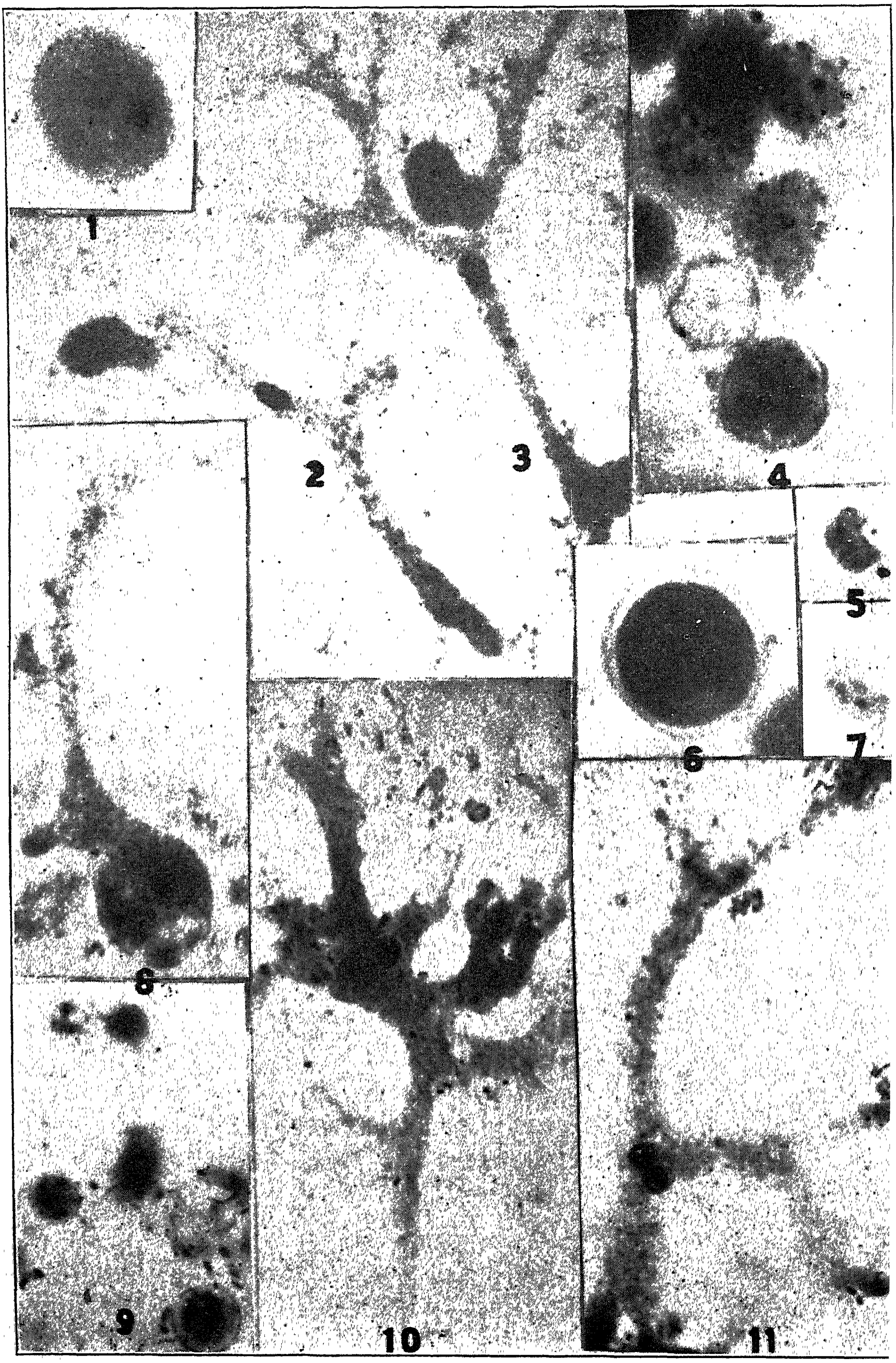
Fig. 7. Amoeba which was formed from a flagellate.

Fig. 8. Plasmodium flowing out of a pre-cyst.

Fig. 9. Pre-cyst of young amoeba.

Fig. 10. Plasmodium in extended form. The karyosome lying against the nuclear membrane.

Fig. 11. Nucleus of the plasmodium undergoing division by promitosis.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THE STRATIGRAPHY OF THE OREGONIA-FT. ANCIENT REGION, SOUTHWESTERN OHIO.

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The Oregonia-Ft. Ancient region is located in the vicinity of the villages of Oregonia and Ft. Ancient, along the Little Miami River in Warren County, southwestern Ohio. It has an area of approximately 50 square miles, and is enclosed principally within the Morrow quadrangle of the U. S. Geological Survey. The region has several times been referred to by geologists*, and the Mound Builders' work at Ft. Ancient is widely known, but there is in the literature no detailed treatment of the stratigraphy of the district.

The author acknowledges his indebtedness to Dr. J. Ernest Carman, of Ohio State University, and to Dr. W. H. Shideler, of Miami University, who have aided very materially by their helpful suggestions and criticisms.

PHYSIOGRAPHY OF THE REGION.

The Oregonia-Ft. Ancient region is located in the Glaciated Plains section of southwestern Ohio. The upland of the region is a gently rolling plain, and the region is thoroughly dissected by a well established drainage system. The trunk stream of the district is the Little Miami River, which crosses our area from north to south in a relatively narrow and steep-sided valley. The distance from rim to rim of the valley is less than a mile, even where widest, and the depth is about 250 feet. Bordering

*Geol. Surv. Ohio, III, Part 1, pp. 381-391.
Proceedings of the U. S. National Museum, Vol. 70, Art. 22, pp. 1-18.
Bull. Scientific Lab., Denison Univ., Vol. XIX, June, 1919, pp. 65-81.

the major valley, there is a belt about one mile wide that is thoroughly dissected by gullies and ravines that are cutting back into the upland. Larger tributaries carry this dissection farther from the main valley, but with decreasing ruggedness, until it merges into the upland topography.

The upland of the region is mantled with glacial drift to an average thickness of about 35 feet. The streams and larger ravines of the district have cut through this mantle of drift, and are cutting into the bed rock beneath. It is along these stream courses that most of the exposures of bed rock in the region exist, but in general the ravines do not give continuous exposures for any considerable distance.

PLATE I.

VARIOUS CLASSIFICATIONS OF THE CINCINNATIAN SERIES.

ORTON (1873)	WINCHELL-ULRICH (1897)	NICKLES-FOERSTE (1905)		ULRICH-BASSLER (1906)		FOERSTE* (1910–11)		CUMINGS (1922)	
Lebanon	Richmond	Richmond	Saluda	Richmond Group	Saluda	Richmond	Elkhorn	Richmond	Elkhorn
			Whitewater		Whitewater		Whitewater		Whitewater
			Liberty		Liberty		Saluda		Saluda
			Waynesville				Liberty		Liberty
					Waynesville		Waynesville		Waynesville
					Arnheim		Armheim		Arnheim
Hill Quarry	Lorraine	Maysville	Arnheim	Covington Group		Maysville		Maysville	
			Mt. Auburn				Mt. Auburn		Mt. Auburn
			Corryville		McMillan		Corryville		Corryville
			Bellevue		Fairview		Bellevue		Bellevue
			Fairmount				Fairmount		Fairmount
			Mt. Hope				Mt. Hope		Mt. Hope
Eden	Utica	Eden			McMicken	Eden	McMicken	Eden	McMicken
			Upper		Southgate		Southgate		Southgate
			Middle		Economy		Economy		Economy
			Lower		Fulton		Fulton		

* Foerste, in the Geologic Map of Ohio, 1920, places the Maysville-Richmond division plane at the base of the Oregonia member of the Arnheim division.

STRATIGRAPHY.

The Oregonia-Ft. Ancient region is situated approximately on the crest of the Cincinnati Arch, and the strata are essentially horizontal and undeformed.

The strata of the region belong to the Ordovician system, and principally to the Richmond sub-series. The subdivisions and classification of the Cincinnatian series have suffered many changes and corrections during the last 50 years, and there is not yet complete agreement on all points. This is especially true of the Maysville-Richmond sub-series boundary, which is well exemplified in our region. It is with this question that this paper is primarily concerned.

The subdivisions of the Cincinnatian series as used by the several authors are shown and correlated on Plate I. The column of subdivisions used in this report, which is a composite from several published columns is as follows, the subdivisions exposed in the Oregonia-Ft. Ancient region being in *italics*. The thicknesses given are for the Oregonia-Ft. Ancient region.

(System)	(Series)	(Sub-series)	(Formation)	(Member)	Thickness
Ordovician..	Cincinnatian	*Richmond*...	Elkhorn		
			Whitewater		24′ +
			Liberty		28′ 1″
			Waynesville....	*Blanchester*	35′ 1″
				Clarksville	24′ 8″
				Ft. Ancient	36′ 8″
			Arnheim.......	*Oregonia*	23′ 9″
				Sunset	35′
		Maysville...	*McMillan*......	*Mt. Auburn*	16′ 6″
				Corryville	15′ 2″+
				Bellevue	
			Fairview.......	Fairmount	
				Mt. Hope	
		Eden........	Latonia........	McMicken	
				Southgate	
				Economy	
			Utica		
	Mohawkian				
	Canadian				

The Cincinnatian series is made up largely of shale, and subordinately of limestone. The general succession throughout the series is an alternation of layers of shale and limestone, the shale layers commonly being thicker. A composite geologic section of the Oregonia-Ft. Ancient region is as follows:

Thickness

THE RICHMOND SUB-SERIES.

THE WHITEWATER FORMATION: 24′ exposed; best exposed in Flat Fork.

42. Irregularly bedded, argillaceous limestone and relatively even-bedded, blue-gray shale....................................12′ 0″

The whole assumes a distinctive cream color upcn weathering. Principal fossils are: *Byssonychia obesa*, *Strophomena sulcata*, *S. planumbona*, *Rafinesquina alternata*, *Rhynchotrema capax*, *Platystrophia acutilirata*, *Hebertella occidentalis*, *Dinorthis subquadrata*, *Monticulipora epidermata*, *Homotrypa wortheni*, *Bythopora delicatula*, *Batostoma variable*, *Streptelasma rusticum*, *S. divaricans* and *Protarea richmondensis*.

41. Alternating layers of irregularly-bedded, argillaceous limestone and nodular shale. Fauna essentially the same as that of Zone 42, except that *Streptelasma rusticum* is especially large and abundant at this horizon.. 6′ 8″

40. Alternating layers of limestone and shale between base of 3½-inch limestone layer at top of zone, and base of "Turkey Track" limestone layer below.. 5′ 4″

This Turkey Track layer is a hard, fine-grained, essentially barren limestone layer approximately 7 inchεs thick, the top of which bears impressions resembling turkey tracks. The base of this Turkey Track layer has been designated by Dr. George M. Austin as the plane of division between the Whitewater and Liberty formations in southwestern Ohio.

Above the Turkey Track layer is a series of hard, fine-grained relatively unfossiliferous limestone layers, most of which bear surface impressions of rill marks or seaweeds. Between these dense, unfossiliferous limestone layers, are layers of blue-gray shale that are relatively fossiliferous. This zone marks a sudden ingress of fossils unusual to the lower Richmond formations. The specimens are not abundant, but a close search will disclose numerous species, several of which are as yet undescribed. Chief among these unusual forms are curved and coiled Cephalopods of the *Gomphoceras*, *Cyrtoceras* and *Trochoceras* types. The Pelecypods *Whitella*, *Ischyrodonta* and *Opisthoptera* and others exist at this horizon.

THE LIBERTY FORMATION..28′ 1″

39. Alternating layers of fine-grained, blue shale and even-bedded limestone.. 8′ 5″

Principal fossils are: *Strophomena planumbona*, *Plectambonites richmondensis*, *Platystrophia annieana*, *Rhynchotrema capax*, *Rafinesquina alternata*, *Hebertella occidentalis*, *Dinorthis subquadrata*, *Rhombotrypa quadrata*, *Streptelasma rusticum*, *S. divaricans*, *Protarea richmondensis* and others. This zone, as well as the other ones of the Liberty formation, are best exposed in Flat Fork and Olive Branch.

38. Limestone zone which in most stream exposures caps a falls above the Isotelus shale zone.. 2′ 5″

37. Isotelus shale.. 5′ 11″

Even-bedded, plastic, blue shale with a few thin limestone partings. At this horizon, in the valley of Flat Fork, a very fine large specimen of the Trilobite *Isotelus brachycephalus* was found. This specimen is quite complete and measures 11¼ inches in length by 8 inches across at the posterior edge of the cephalon. Fragments of Isotelus are common at this horizon, but complete specimens are rare. The principal other fossils found in this zone are: *Calymene meeki*, *Rafinesquina alternata*, *Pterinea demissa*, *Ctenodonta*, *Lophospira bowdeni* and *Columnaria alveolata*.

36. Alternating layers of blue shale and thin limestone partings, which form a series of small falls in most stream exposures........11′ 4″

Fauna essentially the same as that of Zone 37, except that *Plectambonites richmondensis* is especially abundant near the top of this zone.

THE WAYNESVILLE FORMATION:

The Blanchester Member..35′ 1″

Well represented in Blacksmith Hollow, Flat Fork and Olive Branch.

35. Upper Hebertella insculpta zone .... 5′ 7″

Top of zone marked by a 3 to 4 inch, more or less wave-marked limestone layer containing *Hebertella insculpta*, *Strophomena planumbona*, *Rhynchotrema capax* and other fossils. Below this uppermost layer of limestone is a 30 inch division composed principally of shale, relatively barren of fossils. The basal part of this zone is composed of alternating laters of shale and thin partings of limestone, and contains principally the Brachiopods *Hebertella insculpta* and *Strophomena planumbona.*

34. Blue shale with thin limestone partings containing fragments of *Isotelus*, *Calymene meeki*, *Pterinea demissa*, *Byssonychia radiata*, *Tetradium*, *Columnaria alveolata* and *Calapoecia cribriformis*.. 4′ 3″

33. Alternating blue shale and even-bedded limestone layers......10′ 1″

Eleven inches below top of zone is a one-inch, even-bedded limestone layer to which the Brachiopod *Plectorthis scovillei* is confined. Other fossils of the zone are: *Zygospira modesta*, *Rafinesquina alternata*, *Plectambonites richmondensis*, *Platystrophia cumingsi* (?), *Leptaena richmondensis*, *Hebertella occidentalis*, *Homotrypa dawsoni*, *Protarea richmondensis*, *Streptelasma rusticum*, *S. divaricans* and others.

32. Blue shale and thin limestone layers containing *Strophomena nutans* and *S. neglecta*.................................... 2′ 10″

31. Even-bedded, blue shale with a few thin limestone partings containing principally fragments of *Isotelus*, several species of *Pelecypods*, *Leptaena richmondensis*, *Dalmanella meeki* and *Bythopora meeki*... 6′ 9″

30. Thin, irregularly-bedded limestone and nodular shale layers. Fossils jumbled and broken................................. 5′ 8″

29. Lower Hebertella insculpta zone, the base of which marks the Blanchester-Ft. Ancient division plane........................ 0′ 11″

The Clarksville member..24′ 8″

Best exposed in Stony Run, Blacksmith Hollow and Longstreth Branch.

28. Alternating thin limestone and blue shale layers............... 6′ 1″

Principal fossils are: *Strophomena planumbona*, *Leptaena richmondensis*, *Hebertella occidentalis*, *Dalmanella meeki* and *Streptelasma rusticum.*

27. Zone of the usual succession of shale and limestone, containing principally: *Zygospira modesta*, *Plectambonites richmondensis*, *Platystrophia clarksvillensis*, *Leptaena richmondensis*, *Dalmanella meeki* and *Streptelasma rusticum*............................. 5′ 2″

26. Alternating shale and thin limestone layers, crowded with: *Strophomena planumbona*, *Platystrophia clarksvillensis*, *Hebertella occidentalis*, all more or less jumbled together.................. 5′ 4″

25. Coarse-grained, irregularly-bedded limestone layers with thin partings of blue shale. *Dalmanella meeki* abundant, and jumbled together.. 2′ 8″

24. Fine-grained, even-bedded, blue shale commonly referred to as the Orthoceras duseri shale or the Trilobite Beds because of the relative abundance of *Orthoceras duseri* and *Calymene meeki* at this horizon. Other fossils common to the zone are: fragments of *Isotelus*, several species of *Pelecypods*, *Cyphotrypa clarksvillensis*, *Tetradium huronense* (?), and *Stromatocerium huronense* (?)........ 5′ 5″

This zone was formerly classified with the Ft. Ancient member, but Dr. Shideler places it in the Clarksville member because of the existence therein of Tetradium and Stromatocerium—Richmond forms not present in the Ft. Ancient member.

The Ft. Ancient member........ 36′ 8″

Most completely represented in Blacksmith Hollow, Longstreth Branch and Stony Run.

23. Alternating shale and thin limestone layers containing principally *Rafinesquina alternata* and *Dalmanella meeki*........ 3′ 0″

22. Even-bedded, blue shale with thin limestone partings. Base of zone marked by a three-inch, wave-marked limestone layer. Most abundant fossils are: *Pterinea demissa*, *Modiolopsis concentrica*, *Byssonychia radiata*, *Anomalodonta gigantea*, *A. alata*, *Zygospira modesta*, *Rafinesquina laternata* and *Dalmanella meeki*.. 8′ 0″

21. Blue shale with a few thin limestone partings; fossils essentially the same as in zone above........ 8′ 8″

20. Zone of nodular shale and thin, argillaceous limestone layers, with a three-inch dense limestone layer at top of zone. Fossils jumbled and broken........ 3′ 6″

Rafinesquina alternata and *Dalmanella meeki* predominate in number, almost to the exclusion of other forms.

19. Alternating layers of irregularly-bedded, argillaceous limestone and nodular, blue shale containing principally jumbled and broken specimens of *Calymene meeki*, *Cornulites sterlingensis* (?), *Zygospira modesta*, *Rafinesquina alternata* and *Dalmanella meeki*.. 10′ 6″

18. Irregularly-bedded limestone layers with thin shale partings. Shale relatively barren of fossils, and limestone layers composed chiefly of fossil fragments and jumbled specimens of *Dalmanella meeki*........ 3′ 0″

THE ARNHEIM FORMATION:

Best exposed in Blacksmith Hollow and Longstreth Branch.

The Oregonia member........ 23′ 9″

17. Conspicuous zone of nodular, irregularly-bedded, argillaceous limestone layers that weather into lumps. Fossil fragments are abundant throughout the zone, indicating shallow water conditions of deposition, but the only unbroken specimens found were a few *Pterinea demissa*, *Anomalodonta gigantea*, *A. alata*, *Cornulites sterlingensis* (?) and a single *Strophomena concordensis*........ 5′ 6″

16. Alternating layers of coarse-grained, irregularly-bedded limestone and nodular shale. Fossils include those of Zone 17, plus *Cyclonema bilix*, *Rafinesquina alternata*, *Dalmanella meeki*, *Peronopora decipiens*, *Mesotrypa orbiculata*, *Homotrypa bassleri*, *Ceramoporella ohioensis*, *Batostoma varians* and many microscopic size specimens of Pelecypods, Gastropods, Brachiopods and Bryozoa, several of which are undescribed........ 12′ 8″

15. Zone of shale and limestone layers; top marked by even-bedded limestone layer with nodules of Pyrite........ 1′ 2″

14. Dinorthis carleyi zone.. 4′ 5″
Thin layers of shale and limestone containing *Dinorthis carleyi*, *Trematis millipunctata*, *Leptaena richmondensis*, *Stigmatella crenulata*, *Rhopalonaria venosa* and *Batostoma varians*. The first appearance of the Brachiopod Dinorthis carleyi marks the base of the Oregonia member.—(A. F. Foerste, Ohio Naturalist, XII, Jan. 1912, p. 436.)

The Sunset member...35′

13. Lumpy shale and thin, irregularly-bedded limestone layers. The Brachiopod *Leptaena richmondensis* first appears in the Richmond division at this horizon.......................... 1′ 6″
12. Alternating blue shale and thin limestone layers, relatively barren of fossils.. 2′ 3″
11. Irregularly-bedded limestone and nodular shale layers.......... 1′ 9″
10. Zone of nodular blue shale and thin limestone layers. Characteristic fossils are: *Rafinesquina alternata*, *Delmanella meeki*, *Stigmatella crenulata*, *Rhopalonaria venosa*, *Peronopora decipiens*, *Mesotrypa orbiculata*, *Homotrypa libana*, *H. flabellaris*, *Hallopora subnodosa* and *Ceramoporella ohioensis*......................... 5′ 6″
9. Covered interval...15′ 8″
8. Even-bedded, blue-gray shale with thin limestone layers containing principally: *Calymene meeki*, *Dalmanella meeki*, *Stigmatella crenulata*, *Peronopora decipiens*, *Homotrypa libana*, *H. flabellaris*, *Hallopora subnodosa* and *Ceramoporella ohioensis*...... 7′ 4″
Practically all of these are typical Richmond forms, not found in the underlying Mt. Auburn division. The characteristic Maysville fossils, with but few exceptions, either do not continue into the Richmond division, or are recognizably modified. At least half of the species that do survive are hardy forms that have lived on since Bellevue time.
7. Alternating layers of coarse-grained, very irregularly-bedded limestone layers with thin shale partings...................... 1′ 0″
The fossils in this zone are jumbled and broken, indicating shallow-water conditions of deposition. Traced southward into Brown and Adams counties, Ohio, this horizon exhibits strongly developed cross-bedding. And in Kentucky, these strata are ripple-marked, sun-cracked and marked with raindrop impressions, indicating not only shallow water conditions, but a definite period of emergence between the deposition of the Maysville and Richmond subseries in that province.*
The base of this zone is regarded as the plane of division between the Richmond subseries above, and the Maysville subseries, below. Dr. Ulrich would make this horizon the systemic boundary between the Silurian and Ordovician systems.

THE MAYSVILLE SUB-SERIES.

THE MT. AUBURN FORMATION...16′ 6″

6. Blue-gray, even-bedded shale with thin partings of limestone, in which the fossils lie undisturbed in a practically horizontal position. The principal fossils of the zone are: *Zygospira modesta*, *Rafinesquina alternata*, the distinctive Mt. Auburn Bryozoan *Homotrypa pulchra*, *Heterotrypa frondosa* and *Ceramoporella ohioensis*... 2′ 5″
5. Irregularly-bedded limestone and nodular shale layers in which exist *Rafinesquina alternata*, *Homotrypa pulchra*, *Heterotrypa frondosa*, *Hallopora rugosa* and *Ceramoporella ohioensis*, all more or less jumbled together... 4′ 7″

*Personal communication from Dr. W. H. Shideler, Miami University.

4. Alternating layers of irregularly-bedded argillaceous limestone with nodular shale layers.. 4′ 10″
   Platystrophia ponderosa auburnensis, the characteristic Mt. Auburn Brachiopod, is abundant in this zone, but was not found in the zones above.
3. Lumpy shale and irregularly-bedded limestone layers............ 4′ 8″
   Fossils jumbled and broken. Principal species are: *Byssonychia radiata*, *Cyclonema bilix*, *Rafinesquina alternata* abundant, *Platystrophia ponderosa* present but relatively scarce.

THE CORRYVILLE FORMATION..................................15′ 2″ exposed

2. Irregularly-bedded, argillaceous limestone layers and lumpy shale.. 8′ 8″
   Fossils jumbled, with *Rafinesquina fracta* most abundant; other forms are: *Pterinea demissa*, *Zygospira modesta* and the characteristic Corryville Bryozoan *Chiloporella flabellaris*. No Platystrophia ponderosa exist in this zone, the first appearance of this species in the zone immediately above marking the base of the Mt. Auburn division.
1. Alternating layers of shale and limestone containing *Chiloporella flabellaris* and *Rafinesquina fracta*, the latter occurring as jumbled masses at several horizons within the zone...................... 6′ 6″

SUMMARY AND CONCLUSIONS.

The bed rock of the Oregonia-Ft. Ancient region includes Cincinnatian strata ranging in age from the Corryville member of the Maysville sub-series, to the Whitewater formation of the Richmond division, inclusive.

Regarding the controversial Maysville-Richmond sub-series boundary; the preponderance of evidence shows conclusively that it should be placed at the top of the Mt. Auburn division. In our region, indications at this horizon point to a shoaling of the Maysville sea. Traced southward through Ohio and into Kentucky, we find evidence of very shallow water conditions and even temporary withdrawal of the sea at this horizon. There is also a marked faunal break at this horizon. The characteristic Maysville forms, with but few exceptions, fail to pass this stratigraphic break between the Mt. Auburn and Sunset divisions; and those that do survive the transition are hardy forms that have lived on since Bellevue time. And even these surviving forms are recognizably modified. Moreover, the first fossiliferous strata in the Arnheim division carry a characteristic Richmond fauna; forms that for the most part do not exist in the underlying Maysville sub-series, but are typically developed in the succeeding Richmond sub-series.

DRAINAGE CHANGES IN THE VICINITY OF WOOSTER, OHIO.

KARL VER STEEG,
Professor of Geology, College of Wooster.

In a pamphlet* published by the Ohio Academy of Science, Dr. J. H. Todd has presented a paper, setting forth his theories concerning the preglacial drainage of Wayne and adjacent counties. Results of investigations within recent years by G. W. Conrey, G. Coffey and the author, throw serious doubt on the correctness of Todd's conclusions. In the light of evidence now available it seems desirable to offer an explanation in accord with facts.

For a detailed discussion of the old theory of the preglacial drainage, the writer refers the reader to the original paper by Dr. Todd, mentioned in the previous paragraph. For the benefit of those who are without information concerning the problem it is perhaps expedient to give, as briefly as possible, a general lay-out of the preglacial drainage conditions as put forth by Dr. Todd. (Figure 1).

Todd agrees with others who have studied Ohio, that the preglacial drainage in this region was to the north in the direction of Lake Erie, instead of to the south as at present. He traced the course of a large stream by way of the broad, drift-filled valley which extends from Mansfield to Loudonville and Shreve. From Shreve its course was northeastward to Wooster, in the valley now followed by the Pennsylvania Railroad; this railroad follows the old valley from Mansfield to Wooster. From Wooster the stream, it is believed, flowed across a broad divide to a point near Orrville, from which it followed the old valley now occupied by Little Chippewa Creek, where it took a northwesterly course leaving Wayne County north of Sterling. From that point its channel was northward by way of Chippewa Lake, passing to the east of Medina and farther north into the valley now occupied by the West Branch of the Rocky River. Tributary streams joined

*Todd, J. H. "Some Observations on the Preglacial Drainage of Wayne and Adjacent Counties," Ohio State Academy of Science, Special Papers, No. 3, pp. 46-67, December, 1900.

this main or trunk stream at various places. Todd places considerable importance on the bed rock as a controlling agent, determining the direction of flow; emphasizing the significance

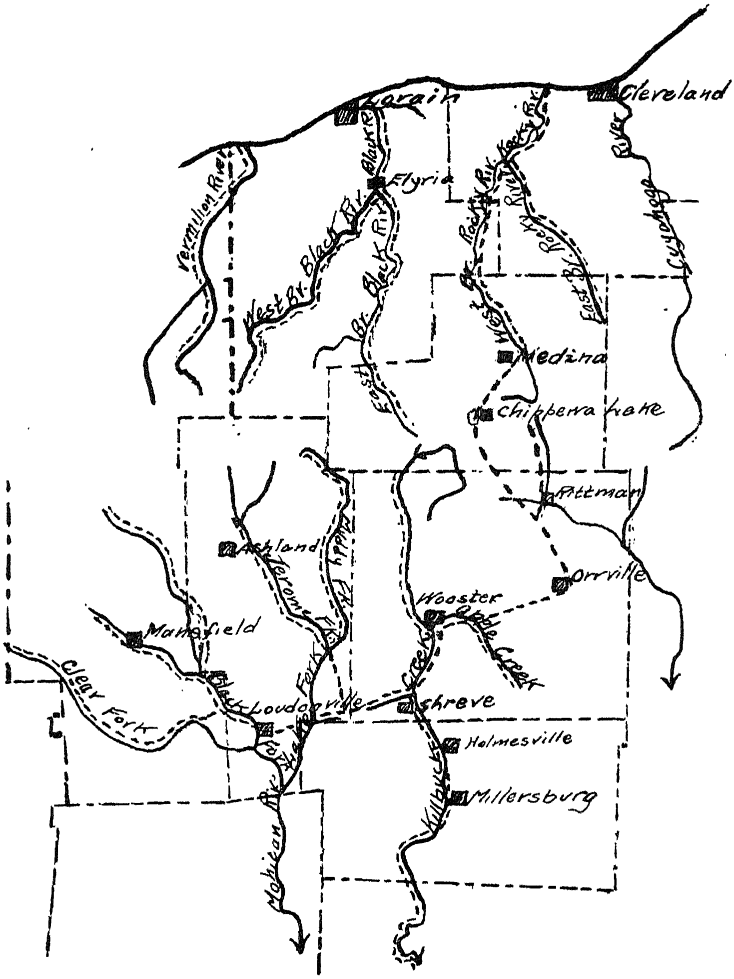

FIG. 1. Sketch map showing present and pre-glacial drainage lines in Wayne and adjacent counties, according to J. H. Todd. Dotted lines indicate pre-glacial drainage.

of the position of the stream between the Waverly-capped hills to the north and west and the Coal Measures to the east and south*.

*Ibid., I, pp 46–49.

The course of the stream can be traced to Wooster (Figure 2) where insuperable difficulties are encountered; the broad valley ends abruptly. Todd recognizes this difficulty, for he remarks†, "This brings me to the city of Wooster, and from here to Orrville I have a rough road to travel, but the preglacial water came here, and there was but one way for it to go out, and I must find that way under the high gravel hills between here and Orrville. On the south of Wooster is Madison Hill, on which is located the Ohio Experiment Station with its quarry

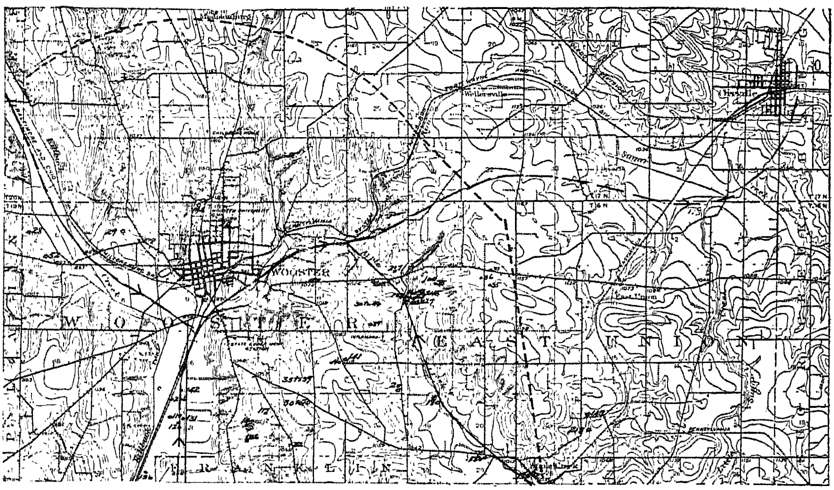

FIG. 2. Pre-glacial drainage lines in the vicinity of Wooster as proposed by Todd. Depth to bed rock obtained from well records are indicated. The heavy dotted line, circumscribed about Wooster, represents bed rock too near the surface for the stream to have passed in that direction.

of elegant Coal Measure sandstone; and 1¾ miles north of it across Apple Creek valley, on a terrace of which is located South and East Wooster, Wooster University is planted on a hill of naked Waverly shale 522 feet above Lake Erie. Madison Hill has about the same elevation, and between them, but near 200 feet below them, sparkles the crystal water of Apple Creek. No drillings have been made in the center of the channel to the rock floor—so its elevation cannot be proven here—but many drillings have been made for water, which is found in white sand at from 95 to 105 feet. One well was drilled to rock on the side of the channel, at the foot of College Hill and showed

†Ibid., I, p. 52.

120 feet to shale; while six furlongs east, across the Apple Creek, at the foot of Madison Hill, rock was found at 45 feet and the channel runs between these two wells."

There is much evidence to support the conclusion that a large preglacial stream did not flow across the divide from Wooster to Orrville. The narrowing channel between Wooster and Madison Hill, as indicated by rock outcrops and well records would seem to exclude all probability that so large a stream flowed to the northeast toward Orrville. There are no differences in the kind of rock or its resistance to erosion which would account for the channel narrowing so greatly here.

If a continuation of the large valley south of Wooster existed beneath the drift between Wooster and Orrville, it would be reasonable to expect a broad sag to indicate its presence. The existence of all the other large preglacial valleys in this section of Ohio are suggested by broad sags. Although not conclusive by any means, the absence of a sag between Wooster and Orrville along the line indicated by Todd as the probable course of the preglacial river, is not in harmony with the theory that a large stream flowed here.

Referring to Todd's course of the stream from Wooster to Orrville as indicated on the map (Figure 2), Conrey remarks* on page 19, "In an attempt to locate this channel, every ravine on the east side of Apple Creek was examined and found to show rock outcrops except in Section 36, Wayne Township, where Spring Run has cut into a preglacial valley, but the existence of rock outcrops near by, both to the north and south would seem to indicate a channel too narrow for the stream which has been traced past Wooster." "The evidence for a preglacial channel leading to the east through the upland from any point near Honeytown seems negative."

The author has obtained well records and carefully examined the valleys leading into the upland, between Weilersville and Apple Creek Village and found bed rock everywhere so near the surface as to exclude any possibility that the stream crossed here. Likewise, to the north of Wooster the bed rock lies everywhere so near the surface that it is evident that the continuation of the stream was not to the north. The heavy dotted line shown on Figure 2 is so placed to indicate the

*Conrey, G. W. "Geology of Wayne County," Geological Survey of Ohio, Fourth Series, Bulletin 24, 1921.

presence of bed rock too near the surface to allow the passage of the stream. A possible avenue for the escape of the waters has been suggested by way of Apple Creek, to Apple Creek Village, and from there to East Union and Orrville through another old channel. There are several objections to this route. First, as already noted, this valley seems too narrow to have accomodated so large a stream as that indicated by the large valley from Shreve to Wooster. It is apparently the valley of a smaller stream, probably a tributary to the larger stream. The trend of Apple Creek valley is such as to suggest that the trunk stream flowed south instead of east. For a tributary to flow into the main stream at an angle pointing in an upstream direction, (Figure 2) is not normal. Apple Creek valley makes the normal angle such as would be made by a tributary, if the trunk stream flowed in a southwest direction instead of northeast as suggested by Todd. Furthermore, it must be admitted that although possible it does not appear to be a reasonable conclusion to assume that the stream would make such an unnatural bend to the south to get to Orrville. The most significant objection, amounting to proof that the stream did not take this round-a-bout route is revealed by well records obtained by the writer. In Section 7, East Union Township and Section 12, Wooster Township, there are numerous oil wells which extend in a narrow belt, in a northeast-southwest direction across Apple Creek. These wells are so located in the valley and on the upland on both sides, as to make possible a cross-section on the bed rock of the old drift-filled preglacial channel. On the upland in Section 12, Wooster Township, the depth to bed rock is only 30 to 40 feet. Farther east, in the same section, it increases to 133 feet. In the valley, near the stream, one well reveals a depth of only 79 feet to bed rock. In Section 7, East Union Township, the well records going from west to east, are respectively, 118, 160, 198, 227, 245, 75 and 36 feet. These records indicate a considerable distance to bed rock and are understandable when one makes allowance for the glacial drift which is thicker on both sides of the valley, on the sides of the stream, where it has not been removed by stream action. The well-head elevation is the important factor to be taken into account. The depths of 227 and 245 feet are not so impressive when we realize that the well-head elevations are 1020 and 1040 feet A. T., respectively, an altitude much above that of the broad valley south of

Wooster, where the elevation is only 844 feet A. T. The greatest depth to bed rock, obtained in the valley south of Wooster is 206 feet. The altitude of the bed-rock floor is therefore 638 feet A. T. The elevations of Apple Creek valley in Section 7 and 12, East Union and Wooster Townships respectively, range from 940 to 960 feet A. T. When the well-head elevations are taken into account we find that the bed-rock floor here cannot be less than 790 feet A. T. This is 152 feet higher than the bed-rock floor in the broad valley south

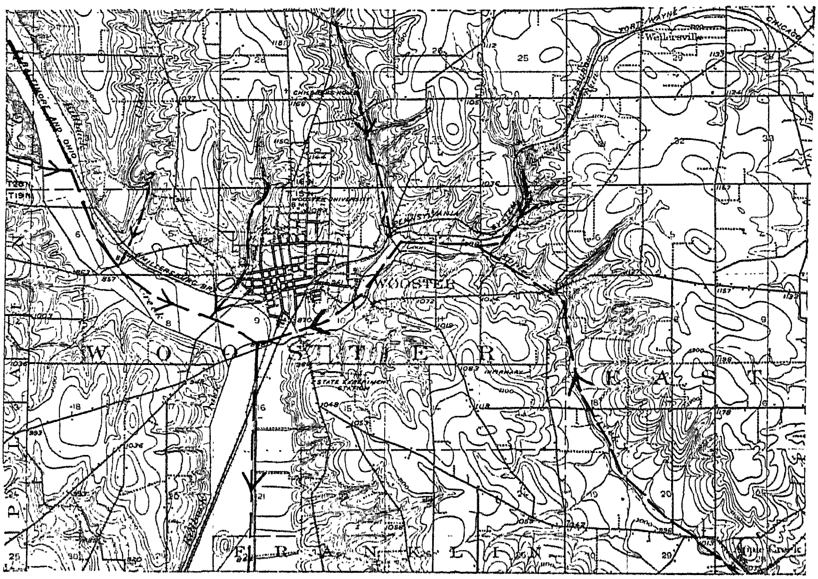

FIG. 3. Pre-glacial drainage lines in the vicinity of Wooster according to the observations of the writer.

of Wooster. Hence it seems impossible that the stream flowed southward by way of the old valley now occupied by Apple Creek.

There is no escape from the conclusion that if the drainage in preglacial time was not north from Wooster and Orrville it must have been south, for that is the only avenue of escape for the waters. The map, (Figure 3) indicates the probable preglacial drainage lines according to the writer's knowledge of the region. It is expected to carry on the investigation still farther with the expectation of offering solutions for the drainage problems to the west and south.

THE ALIMENTARY TRACT OF *PHANAEUS VINDEX* MACL. (SCARABAEIDÆ).*

EDWARD MAJOR BECTON, JR.

INTRODUCTION.

While on a collecting trip to Crane Hollow which is ten miles west of Logan, Ohio, the author noticed the green dung-beetle Phanaeus vindex MacL., was quite abundant in an upland sheep pasture near the Hollow. Upon the suggestion of Dr. C. H. Kennedy the writer spent the day collecting these beetles. The Scarabs were brought back to Columbus alive. They were killed with potassium cyanide, immediately placed in Kahle's Fixative solution and left for two days. The insects were then transferred to 70% alcohol in which they remained from May until fall.

ACKNOWLEDGMENTS.

The author wishes to acknowledge his appreciation to Dr. C. H. Kennedy at whose suggestion and under whose direction the work was carried on. His Lecture Notes and an unpublished thesis, "On the Alimentary Canal of *Megilla fuscilabris*," by Mr. B. J. Landis, have been available for consultation.

Gross Structure of the Alimentary Tract.

The alimentary tract of *Phanaeus vindex* MacL. or *P. carnifex* L. (Scarabaeidæ) is a much coiled though relatively simple structure. In common with most dung-feeding insects the tube is of great length, averaging a little less than eight times that of the body. There are three distinct divisions of the tract; the oesophagus or fore-intestine, the stomach or mid-intestine (mesenteron), the hind-intestine (proctodeum).

The head is flattened so that the front and clypeus extend forward, forming a semicircle as illustrated in Fig. 1. The mouth, which is ventral, is approximately one-third the head length posterior to the front margin.

The buccal cavity is continuous with the pharnyx. The latter converges into the oesophagus, which is a straight, narrow, thin-walled

*A thesis presented for the degree of Master of Science.

tube lying along the mid-line of the body. The posterior limit of the oesophagus is just within the thorax and is marked by the oesophagal valve which separates it from the mid-intestine. No crop or gizzard is present.

The mid-intestine is somewhat larger than the oesophagus and is covered with numerous crypts or papillæ. It continues along the mid-body line until the abdominal cavity is reached. Here the tube begins to coil, making in all nine complete rings of varying circumferences. In Fig. 1 the intestine consists of eight equal coils placed outside the body cavity. To show the length and structure of the intestine it was necessary to be diagramatic in this one instance. The mid-intestine is by far the largest part of the tract, for it averages six and three-fourths times the body length. Just posterior to the oesophageal valve the intestine is often slightly distended but is otherwise of uniform circumference throughout its length.

The four Malpighian tubules arise at the posterior end of fore-intestine. These form a mat of twisted tubes around and in loops of hind-intestine. Following these is a band-like constriction, the pyloric valve. The canal then widens and forms several bends under the dorsal wall of the abdomen. The rectum precedes the anus and appears as a decided enlargement of the hind-intestine. (Fig. 1).

Both fore and hind-intestines are directly attached to the body wall, due to their origin as ectodermal invaginations. The anterior portion of the oesophagus is also supported by fine strands of muscle or connective tissue attached in the head. The mid-intestine lies between the large wing muscles and apparently has no actual supporting tissue. The canal rests free in the abdomen but may be partially held in place by the sac-like tracheæ surrounding it.

The following discussion will deal with the histological structure of the canal, beginning at the anterior end.

The Histology of the Alimentary Canal.

THE PHARYNX.

The pharynx has a heavy chitinous lining which bears short, backward-projecting spines scattered over the surface. The structure is otherwise similar to the oesophagus.

THE OESOPHAGUS.

The intima of the oesophagus is continuous with the cuticula of the body wall and extends the entire length of the fore-intestine, ending in the oesophageal valve. In the anterior portion of the tube it breaks into a series of longitudinal folds which separate preceding the valve. There are no spines in the oesophagus. The primary cuticula is very thin and stains dark with Delafield's Haematoxylin, while the secondary cuticula is thick and almost transparent. The epithelium is composed of a thin layer of cells whose walls are very indistinct, probably due to the fixative (Fig. 2 and 4). There was no apparent basement membrane.

A layer of thin longitudinal muscle strands cover the epithelium. These extend from the anterior end to the region of the valve, where some emerge and continue along the mid-intestine. Due to the strands' interweaving, no long pieces appear in the longitudinal sections (Fig. 2 and 4). Around the longitudinal muscles is a layer of circular muscles which varies in thickness. Toward the oesophageal valve the muscles become more numerous.

Fragments of a peritoneal membrane are found along the oesophagus, indicating that this part of the tube is probably surrounded by it. The membrane is very thin with large, flat nuclei in it. The cell walls are not distinguishable.

OESOPHAGEAL VALVE.

The oesophageal valve divides the oesophagus from the mid-intestine. At this point the mid-intestine and oesophagus seem to have telescoped—the mid-intestine pushing out over the oesophagus, forcing the oesophagus inward, thus partially closing the canal. The narrow epithelium of the oesophagus, in a longitudinal section is bent back to form an S. At the S the layer is somewhat thicker than in other sections and the nuclei are larger. Both divisions of the cuticula continue into the second loop. Outside the epithelium is a dense layer of circular muscle strands. Longitudinal muscles appear as isolated bundles beyond these strands. (Fig. 4).

TRANSITION FROM OESOPHAGUS TO MID-INTESTINE.

The transition of the epithelium of the oesophagus to the columnar type epithelium of endodermal origin is gradual in respect to the change in shape and size. The intima stops abruptly in the interior of the S which denotes a sudden change in the tissue. The first noticeable change in the cells themselves is the appearance of definite cell walls as it continues posteriorly. The cells appear cuboidal and the nuclei round. Gradually the cells lengthen and narrow to the shape typical for the anterior portion of the mid-intestine. The striated border appears and quickly thickens to its average width. In this region the longitudinal muscles come from under the circular and continue along the intestine above the circular muscles.

HISTOLOGY OF THE MID-INTESTINE.

A peritropic membrane is formed in the intestine. This membrane completely encloses the food and continues to surround it throughout the remainder of the canal. Just how or where this membrane is secreted the author was unable to determine.

No intima is present in the mid-intestine.

The epithelium has a striated border lining the lumen. The striæ are very close together and appear to emerge in tufts from each cell. the internal limits of these striæ are not clear. The epithelium is of the columnar type. In the anterior portion they are long, narrow, irregular cells with oblong nuclei. Further along, the cells shorten and thicken with the nuclei becoming oval and granular. Scattered along the basement membrane at the distal portion of the epithelium

are a few small replacement cells or nidi. The writer thinks these cells aré non-functional for there is no evidence to show that they develop into full-sized cells.

At intervals, breaking through the muscle layers are large evaginations of the epithelium. These are known as crypts or papillæ, and in many insects they aid in the increase of absorptive surface or produce secretions. In the latter case they are usually connected by tubes to the lumen of the intestine.

A longitudinal section of a crypt shows it to have a group of nuclei forming a cell nest at its distal extremity. No cell walls are visible in this region. Passing inward, elongate cells form leaving an open space along the mid-line of the crypt. Where the crypt passes through the muscle layers this space appears to be choked with irregular shaped cells. The same cells are loosely scattered between the basement membrane and the muscle layers. No opening into the intestine was demonstrated. In the region of the oesophageal valve a ring of large crypts appear. (Figs. 4 and 10.)

The basement membrane is a structureless partition between the epithelium and the muscles. It is thin but shows heavier than the cell walls.

The position of the muscle layers are reversed in the fore and mid-intestine. In the mid-intestine the circular muscles form a single layer next to the basement membrane. The strands of this layer are thin but numerous. The longitudinal muscles consist of narrow, isolated strands continuous with the strands of the fore-intestine. No trace of a peritoneal membrane could be found.

Attached to the striæ and projecting into the lumen of the intestine are small droplets of secretion which stain in Haematoxylin. From this and the fact that none of the epithelial cells show nuclei moving toward or near the striated border; and that there is no indication of the replacement cells acting, the writer concludes that the secretion is probably merocrene.

PYLORIC VALVE.

A thick-walled structure, the pyloric valve, divides the mid-intestine from the hind-intestine. The valve is lined with a thin intima, which begins on the anterior face of the first fold in the valve. The primary and secondary cuticula stain as in the oesophagus. (Fig. 8).

The epithelium consists of a thin layer of tissue similar in appearance to that found in the oesophagus. The nuclei are small, staining dark in Haematoxylin. The cell walls were not discernible. A basement membrane was not found.

Outside the epithelium is a dense layer of circular muscle strands. This layer becomes thicker toward the posterior end of the valve. Isolated strands of longitudinal muscle are found beyond the circular layer.

TRANSITION FROM MID TO HIND-INTESTINE.

In the posterior portion of the mid-intestine the epithelial cells become very elongate as in the anterior portion and from folds. (Fig. 8).

The cells shorten at the Malpighian tubules beyond which is another fold. In this fold many nuclei are present but the cell walls disappear. Posteriorly the fold diminishes into a thin layer in which no cell walls appear. As the hind-intestine is reached the layer gradually widens, cell walls appear and the cells become the elongate type found in the hind-gut.

The muscle layers are continuous with those of the mid-intestine but the longitudinal muscles apparently end at the posterior end of the valve.

HISTOLOGY OF THE HIND-INTESTINE.

The hind-intestine immediately follows the pyloric valve. It is composed of two regions—the ileum and the rectum.

ILEUM.

The ileum includes most of the hind-intestine. It is a tube of more or less equal diameter until the transition area of the rectum is reached. (Fig. 3). The thin intima of the ileum is continuous and identical with that of the pyloric valve.

Columnar cells of ectodermal origin constitute the epithelial layer. These cells have no striated border. The nuclei are large, oval, and stain granular, while the cytoplasm stains uniformly clear. There are longitudinal grooves in the epithelium, thus all the cells are not of equal height or length. The basement membrane surrounding the epithelium is very pronounced. In places not covered by the muscles it appears as a heavy homogeneous layer.

The circular muscles consist of large, round, isolated, bundles which twist around the tube in a loose spiral. Longitudinal muscles were not found in the region of the ileum nor was there a peritoneal membrane present.

TRANSITION FROM ILEUM TO RECTUM.

The intima gradually thickens due to the widening of the secondary cuticula. The transition of the epithelium is slow from the usual columnar type of the ileum to the flat cells of the rectum. The epithelium produces longitudinal strips or folds which extend along the rectum and project into the lumen of the canal. The basement membrane is continuous from ileum to rectum. Isolated strands of longitudinal muscle appear outside the basement membrane. These strands increase in number toward the rectum. Circular muscles also become more numerous, crossing the longitudinal at right angles.

RECTUM.

The rectum immediately precedes the anus and has the greatest diameter of any part of the canal. (Fig. 7). The intima is heavy due to the thickening of the secondary cuticula. The epithelium is a very thin layer of tissue. Longitudinal folds of this extend far into the lumen of the canal. The nuclei are very small, granular, and oval. The cell walls are not apparent in this layer. The basement membrane is not visible.

Longitudinal muscles are very numerous and closely packed. Where these muscles attach at the anterior end the writer was unable to determine. Several layers of circular muscles are present beyond the longitudinal muscles, the strands of which interlace.

Surrounding the rectum is a thin peritoneal membrane.

In the female beetle attached to the ventral wall of the rectum is the vagina, a portion of which is shown in Fig. 7.

MALPIGHIAN TUBULES.

The four Malpighian tubules are evaginations of the hind-intestine at its anterior limit. Various cross-sections of the tubes show them to be irregular in diameter. The courses of the tubes could not be followed but the author found no evidence to show they were attached except at their origin. (Figs. 5, 6 and 9).

No intima was visible in the tubules. The epithelium is composed of large, irregular cells with large round nuclei. Outside the epithelium is the basement membrane which is continuous with that of the hind-intestine. A layer of connective tissue or muscle surrounds the tubules.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. A dorsal view of the alimentary canal showing all structures in place except the mid-intestine. The ileum includes all of the hind-intestine save the enlarged posterior part which is the rectum.

Fig. 2. A cross-section of the oesophagus.

Fig. 3. A cross-section of the ileum.

Fig. 4. A longitudinal section of the oesophageal valve. One side only is shown.

Figs. 5 and 6. Cross-section of Malpighian tubules showing variation in size.

PLATE II.

Fig. 7. A cross-section of the rectum with a portion of the vagina attached to the ventral surface.

Fig. 8. A longitudinal section of the pyloric valve.

Fig. 9. A longitudinal section of the junction of the mid-intestine and the pyloric valve, showing the entrance of a Malpighian tubule. The tubule is cut at an angle and thus appears closed. C—Portion of crypt.

Fig. 10. A cross-section of the mid-intestine taken midway from its limits.

KEY TO FIGURES.

B. M.—Basement membrane.
C.—Crypt.
C. M.—Circular muscle.
EPI.—Epithelium.
F. T.—Fat tissue.
H. I.—Hind-intestine.
INT.—Intima.
L. M.—Longitudinal muscles.
MALP (MAL) TUB.—Malpighian tubules.
M. I.—Mid-intestine.
NI.—Nidi.
OE.—Oesophagus.
OE. V.—Oesophageal valve.
P. E.—Peritropic membrane.
P. V.—Pyloric valve.
S. B.—Striated border.
T.—Trachea.
VAG.—Vagina.

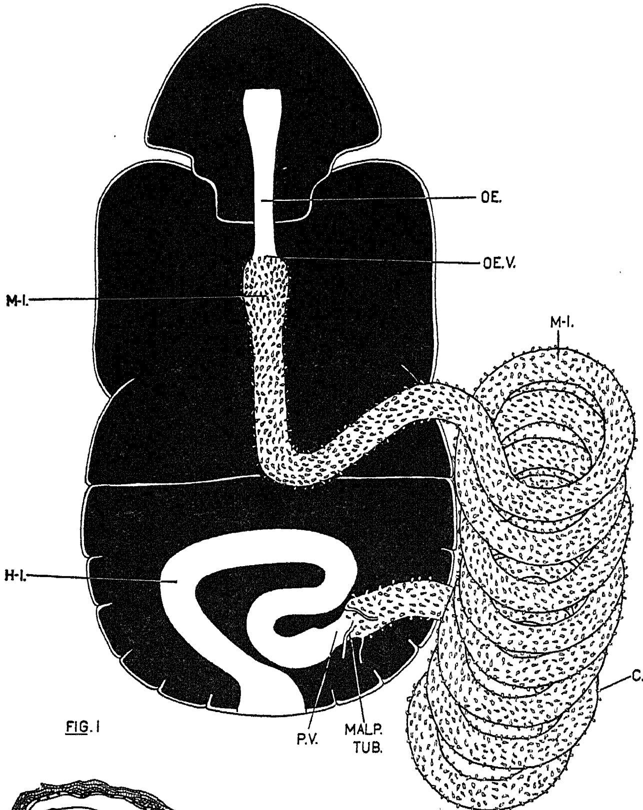


FIG. 1

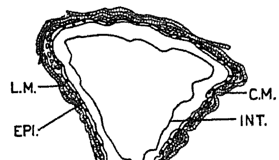


FIG. 2

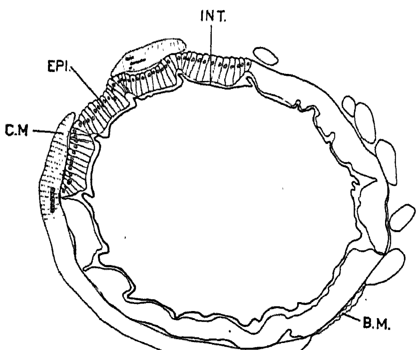


FIG. 3

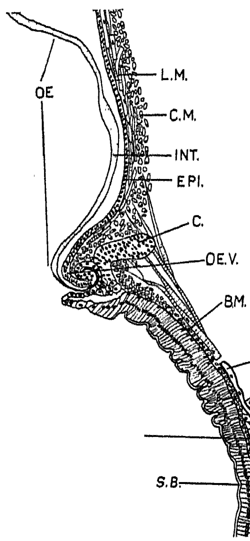


FIG. 4

FIG. 6.

FIG. 5

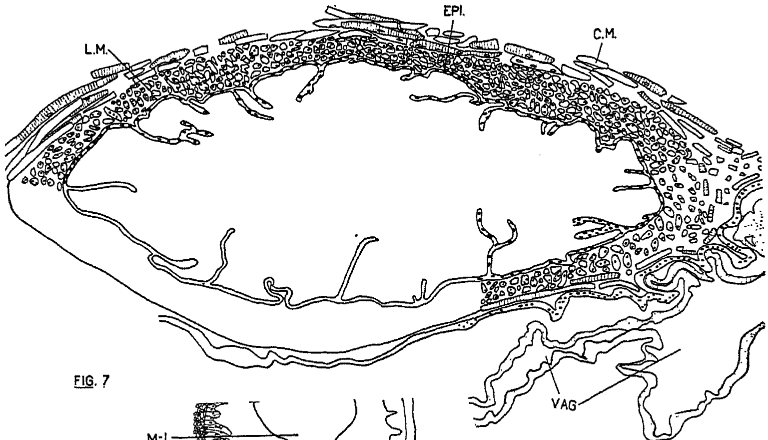


FIG. 7

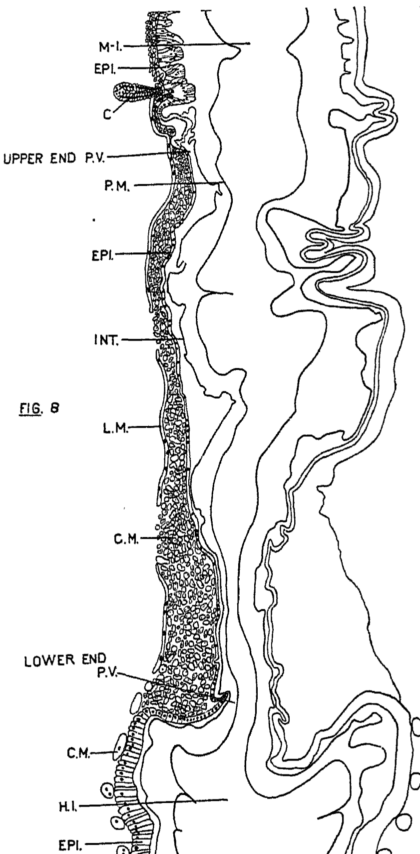


FIG. 8

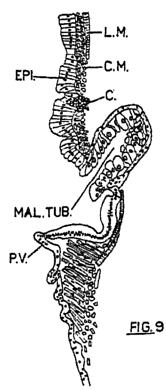


FIG. 9

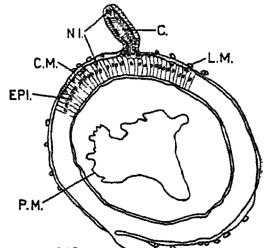


FIG. 10

A STUDY OF THE TARSAL STRUCTURES IN CICADELLIDÆ.*

MARY BLANCHE HOWE.

NOTE.—This article includes extracts from a paper prepared some years ago, but which remained unpublished mainly because of the limited openings for publication at the time. It is believed that the parts here given and reference to the table of species, with the figures which are reproduced entire, will furnish a working basis for further studies in related groups. The structures discussed were first figured by the writer in Bulletin 20, Iowa Experiment Station, p. 714, (1893) and figured and described as cited by Miss Howe in 1912. It may be remarked here that while these structures do not seem to offer evidence of generic affinities, they may prove of value in showing affinities of larger or subfamily divisions and that while there is no constant progression in number for the different instars, there is an evident increase of numbers with the age of the insect.

The nomenclature has been revised to agree with the Van Duzee catalogue. The complete thesis is deposited in the library of the Ohio State University.

HERBERT OSBORN.

HISTORICAL REFERENCE.

In Bulletin No. 108, n. s. (1912) U. S. Dept. of Agriculture, Bureau of Entomology: "Leaf Hoppers Affecting Cereals, Grasses and Forage Crops," by Professor Herbert Osborn, Professor of Zoology and Entomology, Ohio State University, p. 76, the following statement appears, "At the end of the first tarsal joint of the hind legs there is a peculiar microscopic spatulate structure that occurs in varying numbers from the newly hatched nymphs to the adult form. In the specimens studied and figured there were for the first instar one, for the second instar two, for the third instar three, for the fourth instar five, and for the adult insect five." (Illustrated p. 74 Ibid.).

At the suggestion of Professor Osborn the work of investigating these structures has been carried through the species included in the following pages. The specimens were supplied from the University or Professor Osborn's collection. These were mounted in balsam, the entire insect where size permitted, the legs only when size precluded, and in that case the insect is either preserved on pin if not mutilated, or if mutilated the insect is preserved in a bottle after legs were removed for study.

I wish to express my very sincere appreciation to Professor Herbert Osborn for his unfailing kindness, interest, advice and the use of his collection of insects and books.

*Extract from a thesis prepared for the degree of Master of Arts, Ohio State University.

General Description.

In describing these structures the term *platella* is used because the terms pallette, plate, and platelet have been applied to other insect structures differing so much from these that it did not seem fitting to apply them in this case.

These platellæ are small spatulate structures usually located at the end of the first and second tarsal segments, although in a few genera, as is shown in the table, they may be found upon the sides of the first tarsal segment.

These structures vary in form and number, even upon right and left leg of the same insect. On one they may be larger and more fully developed than on the other. Sometimes the first tarsal joint will have five and four. Perhaps on the second tarsal joint they may number one and two. In the table prepared I have shown the variations in the different species in the right and left leg in some specimens and whether specimens were male or female, adult or nymph. I have used the following formulæ for convenience in describing each species:

S—Side of first tarsal segment.
T_1—Apex of first tarsal segment.
T_2—Apex of second tarsal segment.

Also in the last column of table I have placed the names of food plants upon which the species was found.

These platellæ arise from a crown of chitinous scales at the apex of the tarsal joint. They are joined solidly and are immovable. The scales and platellæ seem to develop together, as in the immature forms there is no evidence of the scale upon the tarsal joint where it is not yet divided except where the platella is developed. Evidently they are solid, that is there is no air chamber since when the tarsus was placed in alcohol or Xylol there was no air space as there always was in the tarsi and tibiæ until the liquid penetrated the structure. However, I hope later to test this by cross-sections. The platellæ did not break off readily as they were moved about into position in the balsam before putting down the cover glass.

The drawings are flat outline. Stippling is used merely to indicate the thick heavy chitin at base of platellæ and on a few of the heaviest spines. Spines are omitted where they interfered with the view of the platellæ or seemed to cause a confused appearance in the drawings. The drawings are nearly all made with a 16 mm. objective and an 8 ocular. A

TABLE I

SHOWING FORMULÆ OF PLATELLÆ, AND FOOD PLANTS.

	Left			Right			Food
	Side	T_1	T_2	Side	T_1	T_2	
Acocephalus nervosus	5	6	3	5	6	3	Grass, varied, Vegetation.
Acocephalus nervosus	6	5	3	3	5	2	
Aconura sp.	......	4	2	......	...	...	Coarse Plains Grass.
Agallia sp.	......	2	0	......	...	...	Wheat, Barley, Legumes.
Acinopterus acuminatus	......	4	2	......	4	2	Grass.
Chlorotettix	5	5	4	4	7	4	Grass.
Chlorotettix unicolor	4	6	3	4	6	4	
Chlorotettix unicolor	4	6	4	4	6	3	
Chlorotettix sp.	......	4	3	......	...	...	
Cicadella gothica	......	3	2	......	3	2	Wood Lot.
Cicadula 6-notata......n	......	4	...	......	4	...	Wheat, Grass, Oats, Timothy.
Cicadula 6-notata......n	......	4	1	......	3	1	
Cicadula 6-notata......n	......	3	...	......	3	...	
Cicadula 6-notata......n	......	3	...	......	3	...	
Cicadula 6-notata......n	......	4	1	......	3	1	
Cicadula slossoni	......	3	2	......	3	2	
Cicadula slossoni	......	3	2	......	3	2	
Deltocephalus sp.	......	2	2	......	...	...	Wheat.
D. apicatus	......	2	2	......	2	2	Timothy.
D. apicatus	......	3	1	......	...	...	
Deltocephalus sp.	......	3	2	......	2	1	
Deltocephalus sp.	......	...	...	......	2	2	
Delt. inimicus	......	6	2	......	...	...	Blue Grass.
Delt. pascuellus	......	4	2	......	4	2	
Delt. pascuellus	......	5	1	......	4	2	
Diedrocephala coccinea	......	3	1	......	3	1	Corn, Wheat, Timothy.
Dreculacephala mollipes	3	3	2	3	3	2	Grasses, Oats, Wheat, Rye, Barley Varied.
Euscelis curtisii	......	...	...	......	4	2	Timothy, Blue Grass.
Euscelis curtisii	......	5	2	......	4	4	Wood-lot, Varied.
Euscelis extrusus	......	6	2	......	...	...	Grass.
Euscelis sp.	......	...	...	......	4	3	
Eutetix cincta	......	3	2	......	3	2	
E. semi-nudus	......	4	2	......	...	...	
Gypona 8-lineata var...n	......	5	1	......	6	3	Coarse Grass, Varied.
Gypona 8-lineata var...n	......	5	1	......	5	1	
Helochara communis	3	4	2	4	4	2	Bog, Grass, Juncus, Trees.
Idiocerus sp.	......	3	2	......	...	...	
Jassus olitorius	......	2	2	......	...	...	Varied Shrubbery.
Mesamia vitellina	......	6	3	......	...	...	Conifers.
Phlepsius sp.	......	5	3	......	6	2	Wood-lot, Oats, Wheat, Grass.
P. fulvidorsum	......	5	2	......	5	3	Varied.
P. fulvidorsum	......	4	3	......	5	2	
Platymetopius frontalis	......	3	0	......	3	1	Timothy, Blue Grass, Wood-lot.
Platymetopius frontalis n	......	5	0	......	...	...	
Platymetopius frontalis	......	4	2	......	...	...	
Scaphoideus auronitens	......	4	2	......	...	...	Shrubs, Willows, etc.
Scaphoideus immistus	......	...	...	......	5	2	Varied.
Thamnotettix sp.	......	...	...	......	5	4	Timothy, Red-top.
Tham. clitellaris	......	...	...	......	4	2	Clover, Alfalfa.

few are made with the 4 ocular. This in cases where the tarsi were not contained in the field with the 8 ocular. One *Deltocephalus inimicus* (Figs. 24, 25) with 4 mm. objective shows only the apex of T_1 and T_2 and detail of platellæ.

In the detailed descriptions the species are taken up in the order adopted in Van Duzee's Catalogue.

Description of Structures by Subfamilies.

Subfamily Bythoscopinæ.

In this subfamily the first genus examined was *Idiocerus* (Fig. 1). In the species studied the formula is $T_1 3$, $T_2 2$. These platellæ are elipsoidal and the distal border is narrowed almost to a point, light brown in color, slightly darker than tarsus, rather heavy, flat transversely, but on the perpendicular axis slightly convex to the tarsus. T_1 length .035 mm.; width .015 mm.; T_2 length .03 mm.; width .01 mm. The platellæ arise from a crown of brown chitin which is not so heavy as in some other species.

In *Agallia* the formula for the species studied (Fig. 2) in the specimen examined was $T_1 2$. These are very transparent and delicate, paler yellow than tarsus, flat, spatulate in form. The longer one is almost half the length of the second tarsal joint which is short. They are not set evenly upon the border of the apex of the tarsal joint but the smaller one sets up or back a little from the edge. Each arises from a heavy ring of chitin.

Macropsis and *Bythoscopus* were found to be without platellæ in all the species examined.

Subfamily Cicadellinæ.

Cicadella gothica. The formulæ in this species in the specimens examined were $T_1 3$, $T_2 2$. On T_1 the three platellæ are broadly oval on the distal border, lateral border straight, heavy in texture, set evenly on the apex, slightly convex to tarsus. Length .03 mm.; width .015 mm. On T_2 the two platellæ are set wide apart on the apex. The distal border has more pointed oval sides tapering towards base, dark brown, heavy texture. Length .0275 mm.; width .0125 mm. On both segments the platellæ are slightly darker in color than on the tarsus. (Figs. 3, 4.)

Graphocephala coccinea. (Figs. 5, 6). In this species the formula in the specimen examined is $T_1 3$; $T_2 2$. The platellæ are large, heavy and dark brown, while the tarsus is yellow, and the scales which form the crown of chitin are heavy, long and sharp pointed. The three platellæ on T_1, are similar in form, distal border oval, lateral border straight, flat transversely but slightly convex on the perpendicular axis to the tarsus. Length .04 mm.; width .0125 mm. The platellæ on T_2, are similar to those on T_2 but smaller. Length .03 mm.; width .01 mm.

Subfamily GYPONINÆ.

Gypona 8-lineata var *cana*. (Figs. 11, 14). The formulæ for the specimens examined are: left, $T_1 2$, $T_2 2$; right, $T_1 6$, $T_2 3$. These are rather long and slender, tapering towards both ends, flat pale yellow, unicolorous with tarsus, uniform in size and standing perpendicularly on the apex. Length .05 mm.; width .01125 mm. to .015 mm. The platellæ on T_2 so closely resemble those on T_1 in form and arrangement as to require no separate description.

In the nymphal specimens of Gypona (Figs. 13, 14) there are but two tarsal joints. The formula is 5 for T_1 and 1 where T_2 is beginning to divide. These are set at an angle to the apex, tapering to a point at the distal edge and not very uniform in outline. Length .03 mm.; width .01 mm. Segmentation has begun in T_2, and the platella has developed, short, wider at proximal end, tapering to distal border. Length .02 mm. width .01 mm.

Subfamily JASSINÆ.

Acocephalus nervosus. (Figs. 15, 16). In this species the formulæ for the specimens examined are S5; $T_1 6$; $T_2 3$; both right and left legs. The first platella on the side of T_1, nearest the proximal end is spatulate and transversely concave, flat in the perpendicular axis, widening from the base to the distal border. The other four on the side are somewhat larger, not so much curved, and tapering a little more at an angle of less than 45° from the body. Each one arises from the center of a heavy chitinous ring. At the apex of T_1, the platellæ are more slender, tapering in at the base, spreading out flat transversely, spatulate, and tapering in at the point, slightly concave from the tarsus; length about half that of the portion of the second tarsus extending below it. These are brownish yellow, unicolorous with tarsus, and arise from a heavy crown of chitin. The platellæ at apex of T_2 are similar to those of T_1. In another specimen (Figs. 17, 18) of *Acocephalus* sp. the formulæ are S3; $T_1 5$; $T_2 2$; for right; S6; $T_1 5$; $T_2 3$; for left. In this specimen the platellæ are all translucent and almost colorless.

Mesamia vitellina. (Fig. 19). The formula for the specimen examined was $T_1 6$; $T_2 3$. On T_1 the first four are slender, quadrate with rounded angles, straight lateral borders presenting a rectangle in form. The others are shorter and wider. These do not stand evenly on the apex. The second one overlaps the first one slightly. They vary in length from the first. Length .05 mm.; width .0125 mm.; the smallest length .03 mm.; width .0125 mm., the shorter ones being wider. On T_2, the platellæ are similar in shape to the first four on T_1. Length .03 mm. to .02 mm.; width .01 mm. on all.

These are pale yellow. The crown of chitin from which they arise is a little deeper yellow. Platellæ are unicolorous with tarsus.

Platymetopius frontalis. (Figs. 20, 21.) In the specimen examined the formulæ vary (see table). On T_1, we have 3, 4, or 5 platellæ. These are quadrate with rounded angles, lateral border straight, set evenly in crown of chitin, flat, a very pale yellow, unicolorous with tarsus, thin and transparent.

Length .03 mm.; width .01 mm. Those on T_2 are broader at distal border and rounded, tapering in to the narrow base, otherwise similar to those on T_1. Length .02 mm.; width .015 mm.

On the one nymph (Figs. 22, 23) examined T_1 had 5 platellæ. These were not uniform as in the mature specimens. The second platella from the outer one was longer than the outer one. The others tapered in to the base and were set irregularly on the apex. This seems a characteristic common to all immature forms. On T_2 the line where division was to take place was visible, and the two large spines were developed but no platella.

Deltocephalus inimicus. (Figs. 24, 25.) This is the species especially described by Professor Herbert Osborn in the Bulletin quoted at the opening of this article. In Deltocephalus the formulæ vary as may be seen from the table. $T_1 2$; $T_2 2$; $T_1 6$; $T_2 2$; $T_1 6$; $T_2 2$ is the formula of D. inimicus in the specimen examined, but this specimen is not fully developed, the third tarsal joint not being separated yet. On T_1 the four outer platellæ have straight lateral borders, tapering in towards the base so that they are slightly narrower at the base. They stand perpendicular and parallel with the apex. The two inner platellæ are transversely convex towards the tarsus and stand at a slight angle towards the body of the tarsus. The platellæ are pale almost colorless, unicolorous with tarsus, at the distal end verging into a light brown at base. The crown of chitin is dark and heavy. Length .015 mm.; width .01 mm. Rounded at distal border and tapering in towards base, about half as wide at base as in the widest part.

Cicadula slossoni (Fig. 74, 75). The formulæ for both male and female are $T_1 3$; $T_2 2$, both right and left legs. These are a little stouter and darker brown than the nymph forms of *C 6*-notata, but closely resemble them in shape. The two outer on T_2 are straight with distal border drawing slightly towards a point but in no wise spines. Length .02 mm.; width .0050 mm. They arise from a dark brown almost black crown of chitin. In color they agree with the distal ends of tarsal segments which are darker brown than the body of segments. There is no difference in the structure in male and female.

Gnathodus = *Balclutha* was examined and found to be without the platellæ.

Subfamily Typhlocybinæ.

The species of *Empoasea* examined were without platellæ.

Parallel Structures in Other Groups.

In related groups the only structure resembling this is a formation known as a calcar at the base of the tibia in Fulgoridæ. The formation is used in the Keys to Species (See "A Contribution Toward a Monograph of the Homoptera Insects of the Family Delphacidæ" by David L. Crawford of Stanford Univ. Calif., No. 2041, Proc. of U. S. Nat. Museum, Vol. 46, pp. 557-640. Plates 44-49, March 4, 1914) as "a constant and easily appreciated character of identification."

This calcar is a single large movable spine of varying type, as spiniform, tectiform or cultrate. These forms are further modified by the addition of teeth either coarse or fine along the border. They differ from the structure on the tarsal segments of the Jassids in that they are articulate, there is but one, and it is very large in comparison with the platellæ on the tarsal joints of the Jassids. The writer found no comment as to whether this calcar was the same size in nymphal stage as in adult.

In Cercopidæ nothing similar is found but instead a series of flat hairs fringe the tarsal joints, as is figured in illustration (Fig. 76).

Taxonomic Significance.

One question which presented itself in the investigation of these structures on the tarsal joints of Cicadellidæ was whether they might be of specific or generic value or even of use in defining subfamilies. They are present in every subfamily except Typhlocybinæ. In the subfamilies there are such differences within the group, and such likenesses between genera of different subfamilies that the results as a whole are negative.

In Bythoscopinæ two genera have platellæ but in the two the characteristics are very different. In *Idiocerus* they are dark, heavy and pointed, in Agallia they are delicate, rounded, translucent, more like those on Cicadula. Idiocerus seems more nearly related to the next subfamily Cicadellinæ in this respect. *Cicadella gothica* has platellæ heavy and brown; *Graphocephala* heavy but not so dark; *Draeculacephala* heavy but not dark and no longer pointed but quadrate-angular; *Helochara* heavy but lighter in color, more slender, quadrate-angular, and inclining toward Gyponinæ. *Gypona* has platellæ rather long and slender but comparatively large as the entire leg is large. *Acocephalus* in the next subfamily also large and heavy agreeing with the entire leg in that respect. In *Mesamia vitellina* they are more like *Gypona* but have the quadrate angular tip instead of the tapering form of Gypona.

In *Platymetopius frontalis*, the platellæ are short, broad and thinner in texture, and slightly concave transversely, not at all resembling *Mesamia*. In *Deltocephalus* the platellæ are somewhat similar to *Platymetopius* but more curved in outline, and thinner and more delicate in structure. The entire tarsus is not so heavy as those previously discussed. *Euscelis* is somewhat heavier than *Deltocephalus* and a little longer.

In *Eutettix* the tarsi are heavier and the platellæ are much thinner and lighter in structure. They are broad like *Euscelis*. *Aconura* is more like *Helochara* in the Cicadellinæ, quadrately angular but not quite so slender. *Phlepsius* is even more like *Helochara* in outline and of thick heavy structure. *Acinopterus* returns to the broad flat type and closely resembles *Platympopius* although heavier. *Scaphoideus* again is more like *Phlepsius*, long, slender, and it seems ought to come next to it rather than after *Acinopterus;* or else *Acinopterus* should be placed next to *Eutettix*. *Thamnotettix* again returns to the broad flat type, and the platellæ are set somewhat irregularly on the tarsal joint.

Chlorotettix is quite a contrast to *Thamnotettix*. The platellæ are numerous, long, broad, and straight, on the first tarsal joint arranged with regularity, but somewhat irregular on the second tarsal joint.

In *Jassus olitorius* the platellæ are very heavy and dark, much heavier than any other examined, resembling the early members of the series more, being as heavy, tapering more and larger than *Cicadella gothica*, in form and structure more like Idiocerus than any other. *Cicadula*, the last of the group possessing platellæ is characterized by very small delicate structures more nearly resembling those in *Agallia* than any others.

As a whole the variations are so gradual through the series that if one or two genera were changed about in position no definite particular characteristic could be selected as being sufficiently different from others to warrant its use as a character of generic value, and, as was stated at the beginning of this section, would eliminate but one Subfamily, Typhlocybinæ.

Developmental Significance.

Do they indicate age or instar? In *Cicadula 6-notata* a number of nymph forms were examined to determine if the platellæ varied in number with the instar. The youngest nymphs as indicated by wing development had three platellæ on the first tarsal joint, the next oldest had four and the oldest, but still immature forms, had four on first tarsal joint, and one small platella developing on the first tarsal joint where the division was beginning to take place to form the middle segment of the adult tarsus. In the adult specimens *C. slossoni* the first tarsal joint bore three platellæ, the second joint, two.

In the nymph *Gypona* the second tarsal joint was not separated but one platella had developed at the line of separation. The first tarsal joint bore five platellæ. In the adult specimen one leg bore five and two, the other leg bore six and three. This shows that the development may vary in the two legs of one specimen. Similar variation in other species is shown in the table. This appearance of a less number of platellæ in the *Cicadula* and *Gypona* nymph forms adds proof to the observation quoted at the opening of this paper.

Correlation of This Structure With That of the Food Plants.

In an examination of the various food plants upon which the different genera were found to see if there were any hairs or scales or structures of any kind which might seem to demand the development of these platellæ nothing of special significance was observed in pubescence or scales to indicate a special function for the platellæ. The spines and tarsal claws hold them and serve as a lever when they jump or arise from their resting place. There is nothing unless they afford a broader base and more leverage at the instant of flight but the spines extend so much beyond these structures that they would hardly touch a surface which the spines rested upon, unless the spines penetrated among the small hairs, and the platellæ rested on these hairs of the leaves.

Evolution of the Structures.

In studying the development of these structures, comparison with the other members of the group has been made. Fulgoridæ have a single large articulate spine or calcar on the tibia. The distal border of the tarsal joints in Cercopidæ is fringed with flat hairs. (Fig. 76). In Membracidæ there is one thick short heavy scale on the first tarsal joint and then a rather sparse fringe of delicate hairs. At the same time the diameter across the distal border is very much less, in fact the tarsal joint is almost straight. But in none of these is there any appearance of the spatulate plates or platellæ. This structure seems peculiar to the Cicadelldis alone. The shape of the tarsal joints in Cicadellidæ is more like that in Membracidæ. The spines are coarser and stouter.

The difficulty in homologizing these structures with the hairs of the other members of the group is the fact that the platellæ are rigidly attached. So far as evidence goes they are organs which have originated *de novo* in this member of the group. Their absence in certain genera may be either a primitive or a vestigial condition.

As the Typlocybinæ are distinctly specialized forms it is possible that these structures were eliminated in the evolution of this group, or else that the structure developed in the other divisions of the group after Typhlocybinæ separated from the primitive stem.

EXPLANATION OF PLATES.

Abbreviations—P., platella; S., spine; T_1, T_2, T_3, Tarsi, 1, 2, 3.

Plate I.

Fig. 1. Idiocerus, sp. (imago).
Fig. 2. Agallia, sp. (imago).
Fig. 3. Cicadella gothica ♀, (imago). Right.
Fig. 4. Cicadella gothica ♀, (imago). Left.
Fig. 5. Graphocephala coccina ♂, (imago). Left.
Fig. 6. Graphocephala coccinea ♂, (imago). Right.
Fig. 7. Draeculacephala mollipes ♀, (imago). Left.
Fig. 8. Draeculacephala mollipes ♀, (imago). Right.
Fig. 9. Helochara communis ♀, (imago). Left.
Fig. 10. Helochara communis ♀, (imago). Right.

Plate II.

Fig. 11. Gypona 8-lineata var. ♂, (imago). Right.
Fig. 12. Gypona 8-lineata var. ♂, (imago). Left.
Fig. 13. Gypona 8-lineata var. (nymph). Right.
Fig. 14. Gypona 8-lineata var. (nymph). Left.
Fig. 15. Acocephalus nervosus, ♂.
Fig. 16. Acocephalus nervosus, ♂, (imago).
Fig. 17. Acocephalus sp. (imago). Right Leg.
Fig. 19. Mesamia vitellina, (imago).

PLATE III.

Fig. 18. Acocephalus sp. (imago). Left Leg.
Fig. 20. Platymetopius frontalis (imago).
Fig. 21. Platymetopius frontalis (imago).
Fig. 22. Platymetopius, (imago).
Fig. 23. Platymetopius, (nymph).
Figs. 24 and 25. Deltocephalus inimicus.
Fig. 26. Delt. apicatus, (imago). Left Leg.
Fig. 27. Delt. apicatus, (imago). Right Leg.
Fig. 28. Delt. apicatus, ♂, (imago). Right Leg.
Fig. 29. Delt. pascuellus, ♀, (imago). Right Leg.
Fig. 30. Delt. pascuellus, ♀, (imago). Left Leg.
Fig. 31. Delt. pascuellus, ♂, (imago). Left Leg.
Fig. 32. Delt. pascuellus, ♂, (imago). Right Leg.
Fig. 33. Deltocephalus, (imago).
Fig. 34. Deltocephalus, (imago).
Fig. 35. Deltocephalus, (imago).
Fig. 36. Deltocephalus, (imago).

PLATE IV.

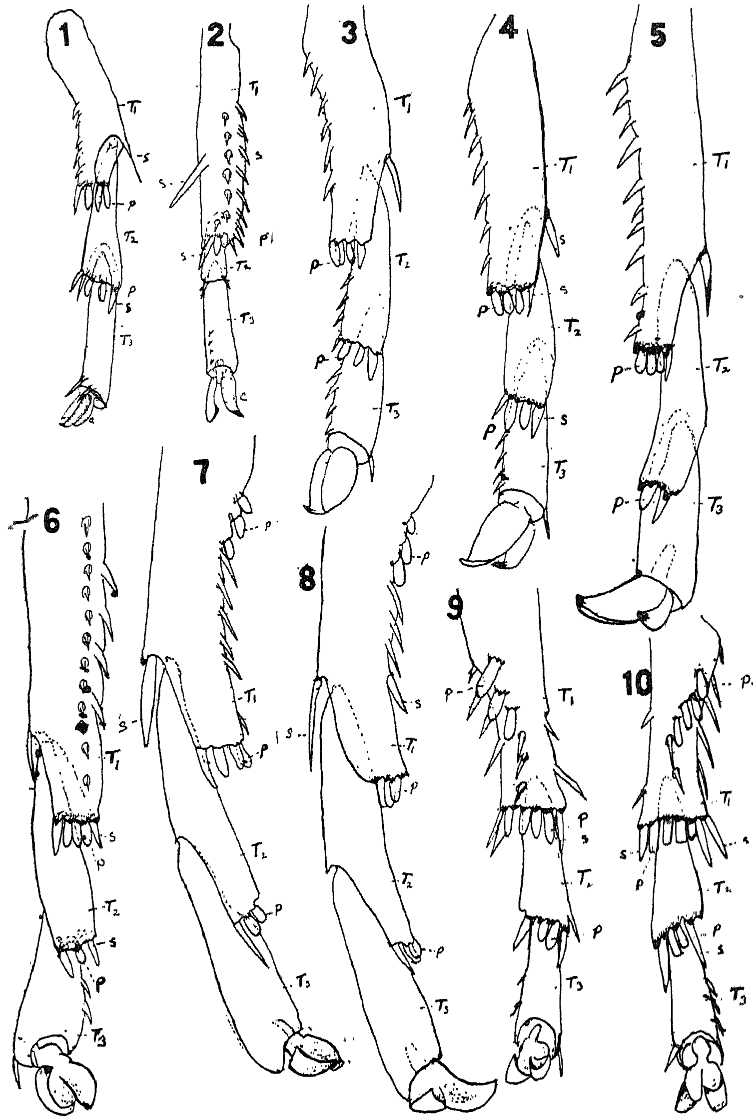
Fig. 37. Euscelis curtisii, (imago).
Fig. 38. Euscelis extrusus, (imago).
Fig. 39. Eutettix cincta, (imago). Right Leg.
Fig. 40. Eutettix cincta, (imago). Left Leg.
Fig. 41. Eutettix semi-nudus ♀, (imago).
Fig. 42. Aconura, ♂, (imago).
Fig. 43. Phlepsius fulvidorsum, (imago). Right Leg.
Fig. 44. Phlepsius fulvidorsum ♂, (imago). Left Leg.
Fig. 45. Phlepsius fulvidorsum, (imago). Left Leg.
Fig. 46. Phlepsius fulvidorsum, (imago). Right Leg.
Fig. 47. Phlepsius sp., (imago). Left Leg.

PLATE V.

Fig. 48. Phlepsius sp., (imago).
Fig. 49. Acinopterus acuminatus, (imago). Left.
Fig. 50. Acinopterus acuminatus, (imago). Right.
Fig. 51. Scaphoides auroniteus, (imago).
Fig. 52. Scaphoideus immistus, (imago).
Fig. 53. Thamnotettix sp., (imago).
Fig. 54. Thamnotettix clitellaris, (imago).
Fig. 55. Chlorotettix unicolor ♂, (imago). Right Leg.
Fig. 56. Chlorotettix unicolor, ♂, (imago). Left Leg.
Fig. 57. Chlorotettix unicolor, ♀, (imago). Left Leg.
Fig. 58. Chlorotettix unicolor, ♀, (imago). Right Leg.
Fig. 59. Chlorotettix unicolor, (imago). Right Leg.
Fig. 60. Chlorotettix tergatus, (imago).

PLATE VI.

Fig. 61. Jassus olitorius.
Figs. 62, 63. Cicadula, (nymph). Right.
Figs. 64, 65. Cicadula, (nymph). Left.
Figs. 66, 67. Cicadula, (nymph). Right.
Figs. 68, 69. Cicadula, (nymph). Right, Left.
Figs. 70, 71. Cicadula, (nymph). Right.
Figs. 72, 73. Cicadula slossoni, ♂, (imago). Right Leg.
Fig. 74. Cicadula slossoni, ♀, (imago). Left Leg.
Fig. 75. Cicadula slossoni, ♀, (imago). Right Leg.
Fig. 76. Cercopidæ. Philaenus lineata, (imago).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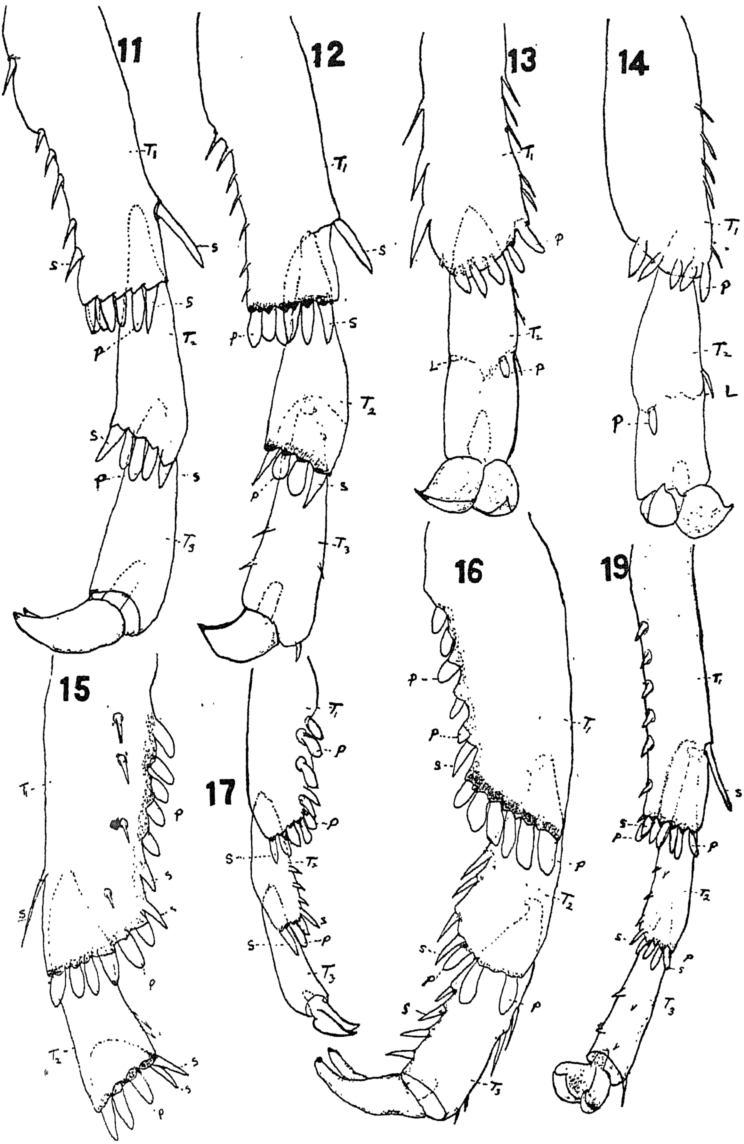
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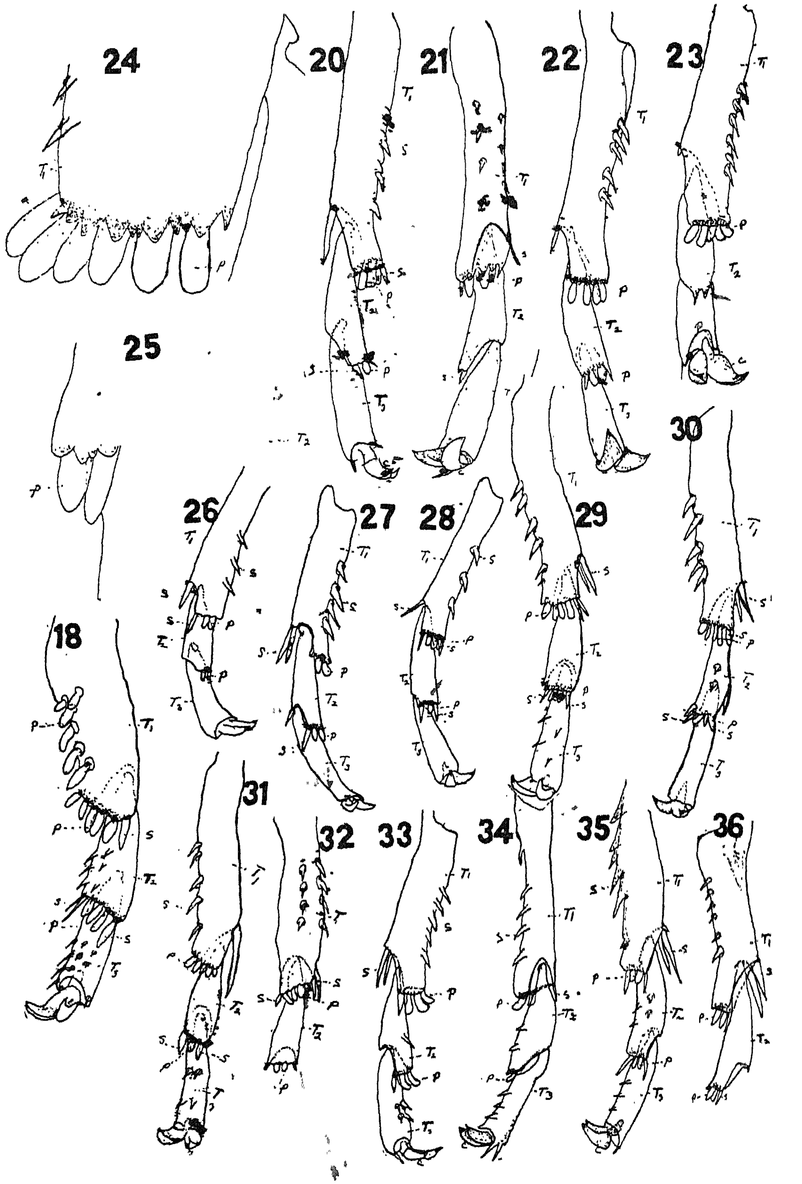
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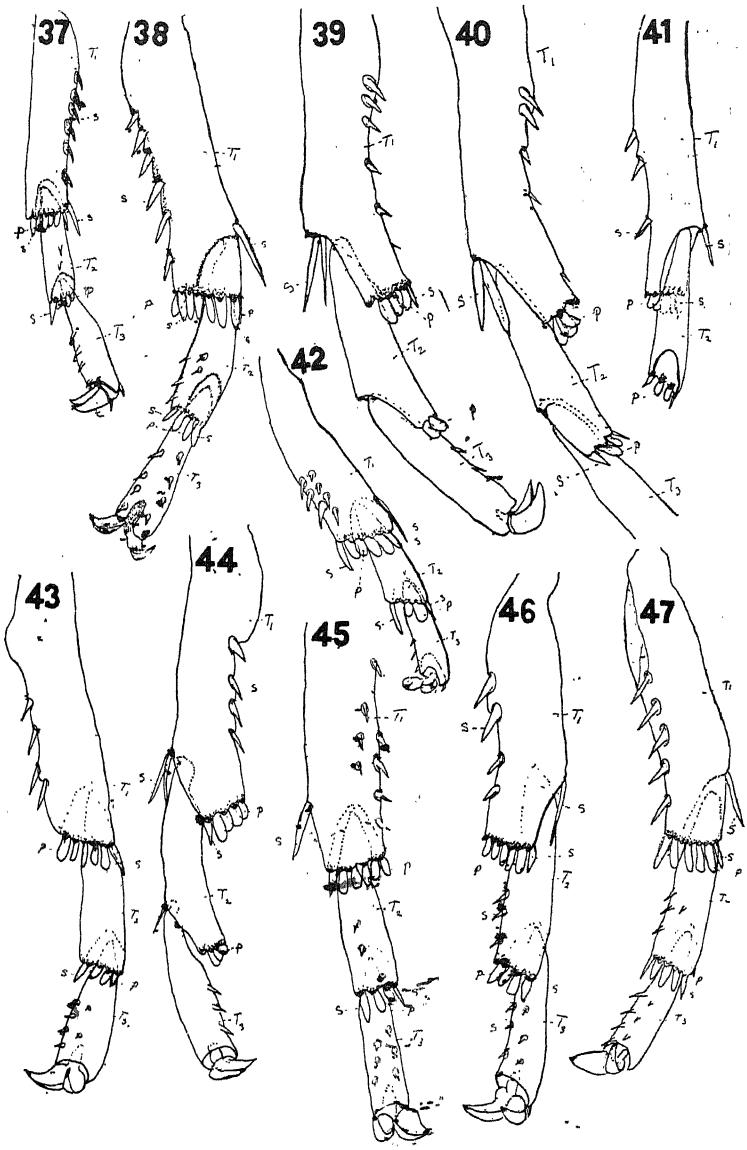
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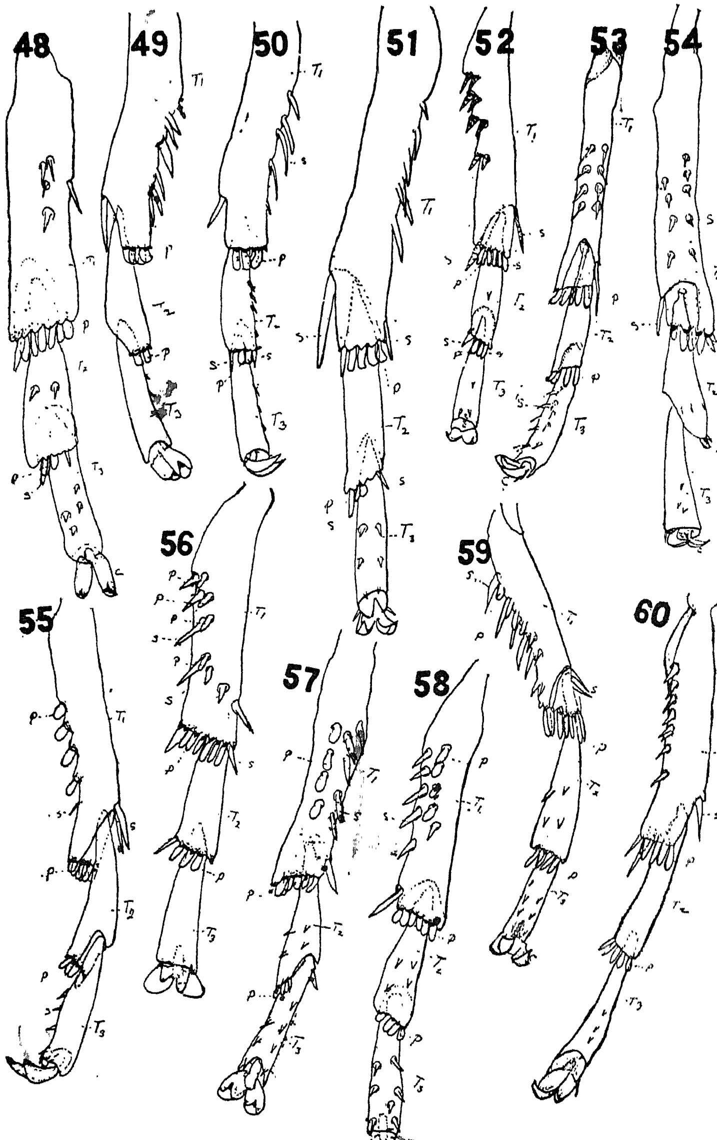
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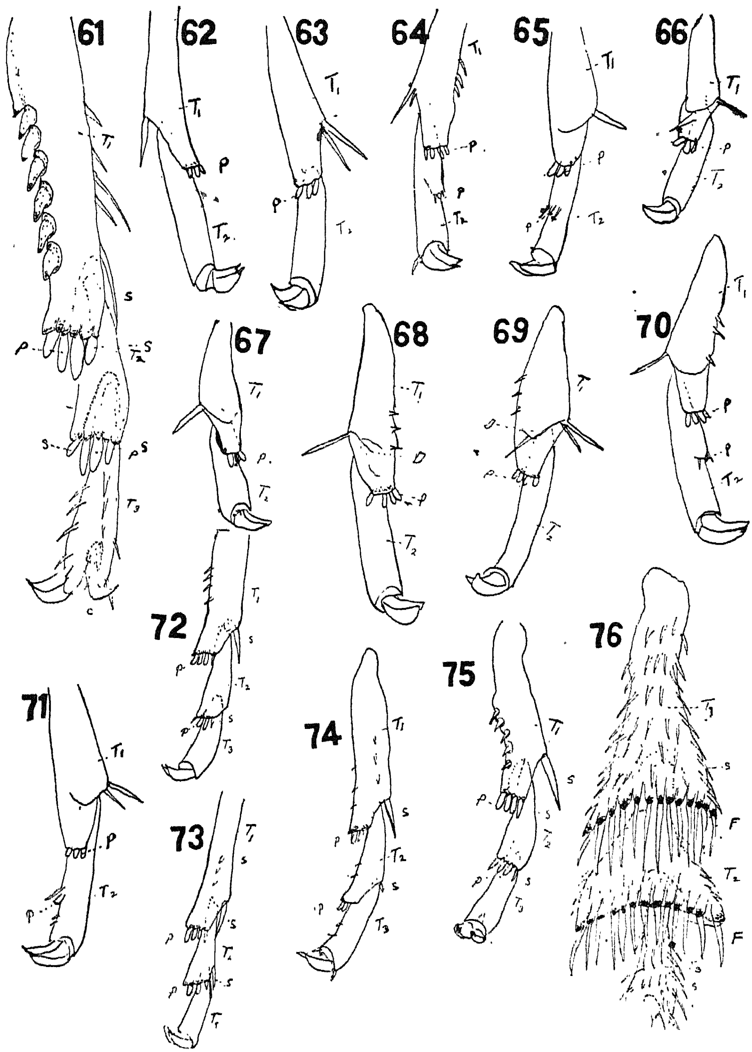
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SUCCESSION IN THE SWAMP FOREST FORMATION IN NORTHERN OHIO.*

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INTRODUCTION.

In descriptions of the deciduous swamp forest formation of eastern North America plant ecologists have generally recognized an elm-ash-soft maple† community. In Northern Ohio this community occurs in the successional series from both marsh and relict bog. In the succession from marsh it follows the willow-poplar association, and in the bog habitats of northeastern Ohio it succeeds the tamarack forest. The swamp forest formation is ultimately invaded and succeeded either by beech-maple of by oak-hickory when the habitat becomes adequately drained through filling or the development of drainage systems. Although the elm-ash-soft maple community has been long recognized, it has usually received but passing mention in the literature. Its composition, local and geographical variants, and its successional or transitional phases are inadequately described.

An attempt to map the forests of northern Ohio in considerable detail‡ led to the necessity of recognizing (1) certain successional or transitional phases of the swamp forest that frequently developed previous to the invasion of beech, hard maple, or white oak, and (2) certain swamp forest communities in which some of the characteristic secondary species of the elm-ash-soft maple community became sufficiently abundant to be classed among the principal dominants. Some of the data obtained are presented in this report partly because they are helpful in interpreting and classifying forest communities often encountered, and partly to suggest conditions and hypotheses that need further investigation.

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†The term soft maple is used in this paper to include both the silver maple (*Acer saccharinum*) and red maple (*Acer rubrum*). The term hard maple includes sugar maple (*Acer saccharum* and *A. saccharum* Rugelii) and black maple (*Acer nigrum*).

‡Sampson, H. C. and Transeau, E. N. Original plant associations as indices to biotic habitats with special reference to the corn borer. Ohio Agr. Exp. Sta. Bul. 429, pp. 152–163, 1928.

A chart showing the approximate habitat range and the order of invasion of trees into the swamp forest formation of northern Ohio is presented as a basis of showing more readily (1) the habitat range of species encountered in the swamp forest, (2) the order of invasion of the swamp forest habitat by the different tree species, (3) the transitional phases of the swamp forest, (4) the variations in relative abundance of individual species, (5) the different forest types encountered in the swamp forest formation, and (6) the relation of present secondary forests to the different phases of the virgin swamp forest.

In order that the reader may have a setting and a glimpse of certain major points that will be developed in this paper the following generalizations are stated at the outset. The commonly recognized elm-ash-soft maple community characteristic of swamp habitats in the Great Lakes region is often correctly designated as an american elm-white ash-red maple association in that these three trees are the dominant species. But in the wetter habitats occupied by the elm-ash-soft maple community, black ash is the species of ash encountered, and in northwestern Ohio silver maple is sometimes more abundant than red maple.

Of much more importance, however, are the two departures dependent upon the order of invasion and upon the variations in relative abundance of the secondary species of the elm-ash-soft maple community.

In the first place the order of invasion of the secondary species is dependent primarily upon drainage conditions. In the elm-black ash-soft maple association pin oak and swamp white oak are the principal secondary species. By the time the drainage is sufficient for white ash to appear as one of the dominants, bur oak and big shellbark hickory also come in as secondary species. With further increase in drainage several other secondary species come in, such as linden, black cherry, shagbark hickory, red and yellow oak, bitternut hickory, and even tulip and walnut. These secondary species are too rare in some localities to appear significant, but in other localities they are sufficiently abundant to attract attention and to suggest transitional phases of the elm-ash-soft maple community as indicated in the chart. The transitional phase characterized by tulip and walnut is not given special mention in the chart, but it is indicated by the length of the horizontal lines in the vertical column representing the red oak-linden transition.

Secondly, and still more important is the fact that some of these secondary species such as oaks, hickories, linden, tulip, and walnut may become so abundant in certain habitats that they are properly classed among the principal dominants of the forest community. In such habitats the expression "elm-ash-soft maple" is obviously a misnomer, and other forest communities corresponding to the transitional phases of the elm-ash-soft maple community mentioned above must be recognized. Terms used to designate these different forest communities are to be considered as tentative until further studies of the swamp forest formation are made. The term swamp forest formation is used in this paper to include the entire successional series of swamp forest communities.

Attention should be called to the fact that the swamp forest formation in northern Ohio is perhaps unexcelled anywhere in the northern and central portions of the Deciduous Forest Formation of North America both in area covered and in the number of tree species represented. It occupies much of the area within the old beach lines of the glacial lakes Maumee, Whittlesey, and Warren. It is the prevailing forest on that part of the old lake bed known as the Black Swamp of northwestern Ohio. On the glaciated area south of the beach lines it continues to be one of the prevailing forest types though seldom occupying large continuous areas. Owing to poor drainage many swamp forest habitats were the last to suffer the encroachment of civilization. Consequently conclusions reached in field surveys were checked by consulting men who knew the virgin forests of certain areas and were able to compare them with the present secondary forests, and with the few relict areas that have been least disturbed.

Of the upland forests of northern Ohio beech-maple is the most extensive and characteristic virgin forest. Of second importance are the white oak-black oak-hickory and the oak-chestnut communities. Other communities occurring locally are oak-chestnut-tulip, the mixed mesophytic forests, white pine, hemlock, beech-maple-hemlock-yellow birch, and big bluestem and bunch grass prairies.

On the old lake bed therefore are areas prevailingly swamp forest interspersed with local areas of beech maple, oak-hickory, or marsh; areas prevailingly beech-maple interspersed with local areas of swamp forest and marsh; and areas prevailingly oak-hickory interspersed with local areas of swamp forest,

marsh, and prairie. The most extensive area of oak-hickory within the old beech lines is in Erie County.

The vegetation on the old beaches differs markedly in passing eastward across the state. In Fulton, Lucas, and Wood Counties White oak-black oak with some hickory is the characteristic forest of beach and sand deposits. In eastern Sandusky County beech and tulip are locally abundant on sand deposits, while in Erie County, oak-chestnut and oak-hickory occupy the sand and gravel deposits. From Berlin Township, Erie County, eastward oak-chestnut and oak-chestnut-tulip are on the dryest sand deposits, and beech-maple becomes one of the principal forests on the beach lines. In Ashtabula County, beech-maple-hemlock occurred locally.

On the morainal drift south of the old beach lines, the prevailing forest is beech-maple interspersed with numerous local areas of swamp forest. Locally areas of oak-hickory similarly interspersed with swamp forests are encountered.

ORIGIN OF THE SWAMP FOREST HABITATS IN NORTHERN OHIO.

The composition of the swamp forest is dependent in part upon previous vegetational history. The physiographic sites in which the swamp forest of northern Ohio has developed are old lake beds, flood-plains, and pre-erosion post-glacial flats. The vegetational history that preceded the swamp forest in each of these habitats may be summarized as follows:

In lake basins: (1) aquatic communities followed by communities characteristic of marshes and of wet prairie, (Jennings[1], Schaffner, *et. al.*[2]), (2) the willow-poplar association of low sand bars and beaches as they emerged (Jennings), and (3) the bog associations (Dachnowski[3], Transeau[4]).

On floodplains: (1) alder and willow-poplar associations, and (2) associations of stream valley bogs characteristic of the Northern Evergreen Forest Formation.

[1]Jennings, O. E. An Ecological Classification of the Vegetation of Cedar Point. The Ohio Naturalist, 8: 291–340, 1908.

[2]Schaffner, J. H., Jennings, O. E. and Tyler, F. J. Ecological study of Brush Lake. Proc. Ohio State Acad. Sci., 4: 151–165, 1904.

[3]Dachnowski, Alfred. Peat Deposits of Ohio. Bull. 16, Geol. Survey of Ohio, 1912.

[4]Transeau, E. N. On the geographical distribution and ecological relations of the bog plant societies of northern North America. Bot. Gaz., 36: 401–420, 1903.

On certain pre-erosion post-glacial flats the deciduous swamp forest communities undoubtedly succeeded forest communities of the northern evergreen forest, such as spruce, balsam, arbor vitae, birch, and probably hemlock and white pine during the later post-glacial migration.

In addition to the natural successions noted above the influences of man have resulted in secondary successions of swamp forests following the clearing of beech-maple on moist uplands, and of bog shrubs and conifer forests in relict bogs.

The virgin swamp forests of Ohio have, therefore, succeeded the pioneer communities of three different climatic plant formations: (1) the bog heath and the bog conifer forest of the Northern Evergreen Forest Formation, (2) the associations of wet prairies, and (3) the vegetation of marshes characteristic of the Deciduous Forest Formation.

HABITAT RANGE OF THE SWAMP FOREST TREES IN NORTHERN OHIO, AND THE ORDER IN WHICH THEY INVADE THE SWAMP FOREST HABITAT.

Owing to the great number of tree species in the swamp forest a fairly definite knowledge of their individual distribution with respect to certain environmental factors is a valuable aid in recognizing the successional phases, and the variations in composition of different swamp forest communities. The accompanying chart made to illustrate certain facts of the behavior of trees as observed in the swamp forest formation of northern Ohio shows the relative distribution of the different swamp forest trees with respect to the combined effects of all the factors of the natural habitat, but it will be considered at first only to show (1) the approximate habitat range of each species that invades the swamp forest in northern Ohio, and (2) the relative order of the invasion of trees into the swamp forest habitat. The chart will be referred to later to illustrate the transitional phases of the elm-ash-soft maple community, the variations in relative abundance of the different species, and the consequent forest types of the swamp forest formation.

The horizontal lines in the chart indicate the approximate habitat range for each species. The habitat range was obtained in the field by using certain plant associations as habitat indices. The different species were first listed according to

Chart showing the approximate habitat range - horizontal lines - and the order of invasion of trees into the Swamp Forest Formation of northern Ohio. The pioneer shrub and tree communities of marshes and bogs which should appear on the extreme right of the chart are omitted. The relative abundance of species - when present - in the different phases of the plant communities cited in the chart is indicated by the following symbols: a = abundant, c = common, f = frequent, o = occasional, r - rare.

Species	Oak-Chestnut Community	Mixed-Mesophytic Community	Beech-Maple Association	Phases of the Elm-Ash-Soft Maple Community: Red Oak-Linden Transition	Bur Oak-Big Shell-bark Hickory Transition	Elm-Black Ash-Soft Maple Association
Acer saccharum Sugar Maple		r-a	f-a			
Quercus alba White Oak	r-a	r-a	r-c			
Fagus grandifolia Beech		r-a	o-a			
Magnolia acuminata Cucumber Tree	r-f	r-a	r-f	r-f		
Juglans nigra Black Walnut	r-f	r-c	r-o	r-a		
Juglans cinerea White Walnut	r-c	f-c	r-o	r-c		
Liriodendron tulipifera Tulip Tree	r-a	f-a	r-c	r-a		
Ostrya virginiana Hop Hornbeam	r-f	r-f	r-f	r-c		
Carya cordiformis Bitternut Hickory	r-f	r-f	r-f	r-o		
Quercus Muhlenbergii Yellow Oak	r-f	r-c	r-f	r-c		
Quercus rubra Red Oak	r-f	r-a	r-c	f-a		
Cornus florida Flowering Dogwood	f-a	o-f	r-f	o-f		
Carya ovata Shag-bark Hickory	r-o	o-f	o-c	f-a		
Morus rubra Red Mulberry	r-f	r-f	r-o	r-f		
Prunus serotina Black cherry	r-f	r-f	r-f	r-f		
Tilia americana Linden, Basswood	r-f	r-o	r-c	r-a		
Ulmus fulva Red Elm	r-f	r-o	r-f	r-o		
Gleditsia triacanthos Honey Locust				r-f	r-f	
Aesculus glabra Buckeye				r-f	r-f	
Quercus macrocarpa Bur Oak				r-a	r-a	
Carya laciniosa Big Shell-bark Hickory				r-a	r-a	
Carpinus caroliniana Blue Beech	r-o	r-f	r-f	f-o	f-c	
Fraxinus americana White Ash	r-c	r-a	r-c	r-a	o-a	
Platanus occidentalis Sycamore				r-f	r-f	r-f
Quercus palustris Pin Oak				r-f	r-o	r-a
Quercus bicolor Swamp White Oak				r-f	r-c	r-a
Nyssa sylvatica Sour Gum	r-f	r-f	r	r-o	r-o	r-o
Ulmus americana White Elm		r-f	r-c	o-a	o-a	o-a
Betula lutea Yellow Birch			r-f	r-f	r-c	r-a
Acer rubrum Red Maple	f-a	f-a	r-c	f-a	f-a	f-a
Acer saccharinum Silver Maple				r-a	r-a	r-a
Fraxinus nigra Black Ash				r-c	r-a	r-a
Populus deltoides Cottonwood				r-o	r-f	r-a

their occurrence or absence in certain plant associations known to represent different degrees of moisture and shade in the habitat. In northern Ohio, the oak-chestnut association* represents the dryest habitats, the willow-poplar association represents the wettest tree habitats, while the beech-maple association represents an intermediate condition of moisture and a maximum of shade. All tree habitats too wet for beech-maple but sufficiently drained for willow-poplar were considered as swamp forest habitats. Within each plant association a moisture gradient may also be recognized partly by the presence or absence of certain species and by the degree of exposure and of drainage associated with the topography and the composition of the soil.

The order of invasion of the trees into the swamp forest habitats is shown on the right side of the chart reading from the bottom of the page upward. The first nine trees at the bottom of the chart are shown extending to the limits of the chart on the right, since all of them invade either the pioneer willow-poplar or the tamarack forest neither of which are included in the chart, but may be assumed by the reader as placed to the right of the chart presented.

After the general habitat range of species with respect to plant associations was obtained, slope and the elevation of low ridges and knolls were then used as an index to the soil moisture gradient within the swamp forest habitat. To one unaccustomed to a flat landscape much of the old lake bed in Northern Ohio at first appears to be level. Closer observation and measurements, however, often show an abundance of low ridges and knolls with gentle slopes of but a few feet per mile. These rather slight differences in topography and consequent differences in surface drainage are reflected in the distribution of tree species. Many of these ridges are but a few inches to a few feet in height but often afford sufficient surface drainage for beech-maple or oak-hickory. On others different phases of the swamp forest are encountered. Internal drainage due to differences in soils was not measured, but soil differences, such as differences in amount of sand, muck, loam, and heavy clay, that could be readily recognized were noted. These marked differences in soils—with some exceptions for sand—appeared

*The oak-chestnut community as represented in the chart includes both the oak-chestnut association and the oak-chestnut-tulip association.

to have relatively little effect upon the *order of invasion* of wet habitats by most of the tree species. Variations in drainage on different areas of the same soil type may be great enough to encompass the whole order of invasion shown in the chart from the elm-black ash-soft maple association to the beech maple association. Furthermore the order of invasion of swamp forests by the principal tree species has been found to be consistent for hundreds of swamp habitats in central and northern Ohio and consequently upon many different soil types. As a result of the above observations, and since soil surveys of several counties in northern Ohio are now in various stages of completion it seemed advisable to postpone detailed studies of the effects of soil types until soil maps are available. Soil maps of Lake and of Sandusky County are now available, and a brief statement of the soil types of northern Ohio by Conrey* is also available.

Briefly, the order of invasion of the elm-ash-soft maple community by different species as drainage conditions increase was arrived at in the feld (1) by listing the different species in the order of their invasion as one ascended a gentle slope from the edge of a marsh or lake or from the center of a depression within the swamp forest, (2) by comparing the distribution of species on adjacent low knolls and ridges of slightly different elevation, but of similar soils, and (3) by comparing the distribution of species on gentle slopes of similar soils, but varying in grade from slopes of one or two feet per mile to several feet per mile.

Owing to the great number of species involved and to the high degree of sensitiveness of the trees to slight changes in drainage, consistent data for all species may be expected only when very gentle and uniform slopes are studied. If the slope is abrupt, sufficient space between critical moisture conditions is not available for a definite zonal grouping of all of the species and the order of invasion is obscured. Perhaps the most irregular conditions are encountered in swamp forests in which the area is dotted with numerous small elevations just large enough to support one or a few mesophytic trees. Any one of several mesophytic trees may occur on the different individual knolls resulting in a forest as a whole that is composed of a

*Conrey, G. W. Soil fertility and soil types as indices to biotic habitats. Ohio Agr. Exp. Sta. Bul. 429, pp. 163–168, 1928.

mixture of swamp and upland trees; a mixture that might readily be confused with the mixed mesophytic community.

Elevation above the lake may be ignored, since the angle of the slopes is more important than absolute elevation. In many swamp forest habitats an abrupt elevation of seven to ten inches gives sufficient local drainage for beech-maple or oak-hickory. On the other hand a slope of three or four feet per mile may lead to an elevation of several feet above the lowest depression yet not be sufficiently drained for beech-maple. Consequently when drainage conditions and tree distribution on low knolls and ridges of slight differences in elevation are compared these elevated areas should be near one another, and both slope and kind of soil should be considered.

Locally, knolls of a few yards or a few rods in extent may be so abundant in a swamp habitat as to permit the development of mosaic forests consisting of a continuous swamp forest dotted with small island-like groves of forest types characteristic of better drained areas. The knolls may be composed of sand or of loams.

The order of invasion of the species into the swamp forest as shown to the right of the beech-maple in the chart is dependent upon their endurance of poor drainage or lack of soil aeration. The dropping out of several of these species and the decreased abundance of others when the habitat becomes better drained and is invaded by beech and hard maple is apparently the result of starvation in the dense shade of the latter species, since many of the swamp forest species grow abundantly as secondary forests in these habitats when beech-maple has been removed by clearing or when light is allowed to penetrate the forest canopy by the removal of one of the older trees. The order of dropping out of species as shown to the left of the beech-maple in the chart is dependent upon their endurance of desiccation. It appears that the major controlling factors of the external environment are the combined effects of light, moisture gradient, and soil aeration.

The data in the chart are based upon hundreds of field observations in the least disturbed areas now available. All of the species recorded were not sufficiently abundant in single habitats to determine their order of endurance of poor drainage. Hence each species had to be checked against another time after time in numerous habitats until the order of the whole series was determined. Most attention was given to the

limitations of species considered most significant for the region. The rare occurrence of some of the secondary species in all habitats leaves some doubt of the accuracy of the limitations indicated for them in the chart. A few secondary species are omitted from the chart, but are listed in the body of the paper. The limits of the habitat range indicated on the left side of the chart are based upon fewer data than those on the right.

While the chart is subject to refinement by further observation, by physical determinations of the soil moisture gradient at different seasons, and by experimental tests, it is sufficiently accurate to furnish a basis for the interpretation of the successional or transitional phases of the swamp forest in northern Ohio, and also for certain variations in both virgin and secondary forests.

SUCCESSIONAL OR TRANSITIONAL PHASES OF THE ELM-ASH SOFT MAPLE COMMUNITY.

In swamp habitats where the increase in drainage and soil aeration is very gradual certain successional phases of the elm-ash-soft maple community become evident. In the wettest habitats it is an *Ulmus americana—Fraxinus nigra—Acer rubrum* or *Acer saccharinum* swamp forest community. The secondary species when present in this first phase are sour gum, yellow birch, swamp white oak, pin oak, sycamore, cottonwood, black willow (*Salix nigra*), peach-leaved willow (*Salix amygdaloides*), and trembling aspen (*Populus tremuloides*).

As already pointed out in the introduction, transitional phases of the elm-ash-soft maple community may develop as a result of the order of invasion of its secondary species. Hence a second phase of the elm-ash-soft maple community is recognized when sufficient drainage exists for the entrance of white ash, big shell bark hickory, and bur oak apparently in the order named. There appears to be little difference in the endurance of poor drainage by these three species in natural habitats. Even with the entrance of these species the swamp forest usually remains an elm-ash-soft maple forest and is correctly designated the *Ulmus americana—Fraxinus americana—Acer rubrum* association, though in certain habitats the oaks and hickory also become prominent species. In secondary forests the prominence of oaks and hickory is not unusual. This phase of the swamp forest occupies a sufficient area of

gentle slopes in northwestern Ohio to deserve recognition. For convenience of reference this phase of the swamp forest may be designated the bur oak-big shellbark hickory transition, with the understanding that the name merely refers to the fact that drainage has become sufficient for these two species.

Certain other species also come into this phase of the swamp forest. Carpinus is usually present. Buckeye, honey locust, box elder (*Acer negundo*) and hackberry (*Celtis occidentalis*) are more infrequent in occurrence.

Still a third phase of the elm-ash-soft maple forest becomes evident when increased drainage has made possible the entrance of red elm, linden, cherry, mulberry, shagbark hickory, flowering dogwood, red oak, yellow oak, bitternut hickory, and hop hornbeam. Even with the entrance of these trees elm may continue to be the most abundant tree and many communities may be appropriately designated an elm-ash-soft-maple community or association. But the large number of species now present makes possible several variations in composition and, as will be shown later, in certain habitats the oaks and hickories also become prominent. Perhaps the most convenient name for this phase of the elm-ash-soft maple community is the red-oak-linden transition, with the understanding that the name does not necessarily refer to the prominence of these species but to the fact that drainage has become sufficient for them.

Additional species that may be found in this phase of the swamp forest are green ash (*Fraxinus lanceolata*), blue ash (*Fraxinus quadrangulata*), red ash (*Fraxinus pennsylvanica*), Kentucky coffee tree (*Gymnocladus diovica*), mockernut hickory (*Carya alba*), and fire cherry (*Prunus pennsylvanica*). In northeastern Ohio hemlock occurs sometimes as a relict in this phase of the swamp forest.

Still a fourth phase of the elm-ash-soft maple community sometimes becomes evident before invasion by beech, hard maple, or white oak. Its existence is dependent upon the entrance of tulip, white and black walnut, and magnolia into the swamp forest slightly before the invasion and dominance by beech. In this transitional phase of the swamp forest may be found individuals of all of the species named above, yet in many habitats elm-ash and soft maple may be the most prominent trees. In keeping with the terminology already used for the other phases of the swamp forest, this final phase may be designated the tulip-walnut transition.

The last three phases of the swamp forest are not always evident in a particular site. They may be evident on low ridges of slightly different elevation, in shallow depressions of different depths and degrees of drainage, and on very gentle slopes, but if the slope from the swamp forest to the upland forest is noticeably abrupt the assortment of the above species in the narrow fringe of forest at the edge of the swamp is not evident. Neither is it evident in swamp forests dotted with, numerous knob-like elevations upon which only one or two of the more mesophytic trees may grow.

While the above observations were made mainly upon swamp forest habitats that originated in marshes additional observations show that similar conditions exist in swamp forests originating in conifer bogs, and on flood plains. In fact the mixed forests on some of the flood plains of this region are more readily comprehended in the light of the facts stated above. These transitional phases may occur either where beech-maple or where oak-hickory is the upland forest. They also occur in the very numerous local swamp forest habitats in the beech-maple or oak-hickory forests on the glacial morain south of the old beach lines. Here the relative depth and drainage of the different depressions are at once characterized by the one or the other of the above transitional phases of the elm-soft-maple community, or by the corresponding forest community to be described under the following topic.

SWAMP FOREST COMMUNITIES RESULTING FROM VARIATIONS IN THE RELATIVE ABUNDANCE OF THE SECONDARY SPECIES OF THE ELM-ASH-SOFT MAPLE COMMUNITY.

As already pointed out the elm-ash-soft maple community may include an elm-black ash-red or silver maple association and the succeeding elm-white ash-red maple association. The latter association may further be considered in certain habitats as consisting of at least three transitional phases depending upon the order of invasion of its prominent secondary species. We come now to a brief consideration of a more fundamental modification of this association brought about by the relative increase in abundance of some of the secondary species that places them among the dominants of certain habitats. The resultant swamp forest communities correspond, in the suc-

cessional series, to the transitional phases of the elm-ash-soft maple community already described, but they are not dominated solely by elm, ash, and maple. In fact some of the secondary species may be more abundant than either ash, maple, or elm.

Attention is again called to the chart in which the relative abundance of species in different habitats is indicated by the following symbols: a = abundant, c = common, f = frequent, o = occasional, r = rare to absent. Two letters are used for each species since a considerable variation in the relative abundance of individual species is found when hundreds of observations are made. The letters refer to the relative abundance of the species in the virgin forests.

In the vertical column representing the elm-black ash-soft maple association yellow birch, pin and swamp white oak are recorded as rare to abundant. From the data at hand it appears that these oaks were usually only rare to frequent secondary species in the elm-ash-soft maple community of northern Ohio, and that the yellow birch was entirely absent in the swamp forests of northwestern Ohio.

In the column representing the bur oak-big shellbark hickory transition, or the wetter phase of the elm-white ash-red maple association, bur oak and big shellbark hickory are recorded as rare to abundant. They reached their greatest abundance in the swamp forests of northwestern Ohio.

In the column representing the red oak-linden transition, or the better drained phase of the elm-white ash-soft maple community, many secondary species are recorded. Several of these species frequently become abundant in this phase of development of the swamp forest formation in northern Ohio; principally red oak, shagbark hickory, linden, bur oak, and big shellbark hickory; while yellow oak, red elm, and bitternut hickory became conspicuous secondary species. In the best drained phases of the swamp forest formation tulip and walnut become abundant enough in certain habitats to be classed with the dominants.

This variation in relative abundance of species results in the development of several forest communities in the swamp forest formation. Which of these communities are extensive enough to be recognized and named? What are the most appropriate names for them? Satisfactory answers to these questions may be obtained only by a combined study of the

records of early surveys and present field studies, including inquiry among men who removed the virgin forests.

Sears* has studied the early surveyor's records of this region but his published data while helpful are too generalized to aid in the solution of some of the problems. Data from all of these sources were brought together in the present survey, but so much more remains to be done that only tentative answers may be proposed for the above questions at the present time.

The local abundance of yellow birch in the elm-black ash-red maple association in northeastern Ohio occurs in those habitats, principally bogs, that were dominated by communities of the Northern Evergreen Forest Formation until very recent times. The elm-black ash-red maple-yellow birch community, therefore represents a particular transition in the succession from the Northern Evergreen to the Deciduous Forest Formation.

Excessive abundance of pin oak and swamp white oak in the virgin forests of northern Ohio seems to have been quite local and probably associated with the occurrence of heavy clay soils. A pin oak type is already recognized by foresters, and it is perhaps sufficient merely to recognize that transitions may exist between the pin oak community and the elm-ash-soft maple community.

Bur oak was an important secondary species in the virgin elm-ash-maple community in northwestern Ohio. Much of it was cut for the building of ships in the early days of settlement. The area over which bur oak should be classed as a dominant along with elm, ash, or big shellbark hickory is undetermined. Perhaps this community is not extensive enough to deserve a special name except as a local variant, since a bur oak-elm association that succeeds wet prairie is already recognized.

Owing to the great number of species involved a much more complex situation is met when the forest communities corresponding to the red oak-linden transition in the successional series are considered. Since several of these secondary species of the elm-ash-soft maple community may occur as dominants in certain areas, several combinations of dominants are possible and several resultant forest communities may occur. Perhaps the most helpful classification of these communities will result from a general agreement among foresters and ecologists to

*Sears, P. B. The natural vegetation of Ohio. Ohio Jour. Sci. 25: 139–149, 1926. Ibid 26: 213–231, 1927.

choose one or two names such as red oak-linden-ash, red oak-linden-elm, or the mixed red oak-linden-ash community, that have a wide geographical significance and to consider the remaining combinations wherever found as variants. For example, in certain habitats in Portage County, Ohio, one might recognize an elm-shagbark hickory-red maple variant of this community. The remaining species of the red oak-linden transition occur in this variant but are rather infrequent. As a result of this variant in the successional series before invasion and dominance by beech, wet beech forests with elm, hickory, and red maple as the principal secondary trees are sometimes found in Portage County. In some variants the oaks and hickories characteristic of the elm-ash-soft maple community are so abundant in the least disturbed swamp forest relicts in northwestern Ohio that the forests have the characteristic physiognomy of an oak-hickory association. They can be distinguished from the upland white oak-black oak-hickory association only by their species composition.

The climax of luxuriance is reached in the swamp forest formation when drainage becomes sufficient for tulip, walnut, and magnolia to intermingle with the other species of the elm-ash-soft maple community. In certain habitats where the soil is composed of sandy or gravelly loam, tulip and walnut may be as abundant as the other dominants of the forest community. In special habitats where several species of this tulip walnut transition become about equally abundant, and in which beech and maple have become fairly common as a result of further drainage, the resultant mixed forest community resembles the mixed mesophytic community that sometimes develops as a special transition between beech maple and oak-chestnut. But this point will receive further consideration in a later paper.

Local societies of single species also occurred in the virgin swamp forests of northern Ohio. The early settlers report small areas of almost pure stands of cottonwood, black walnut, sycamore, elm, tulip, hickory, and pin oak. Pure stands of cottonwood are reported occupying as much as forty acres. John Coutches reports a pure stand of walnut covering almost a section of land on the site now occupied by the Standard Oil Company in the eastern part of Toledo. "The soil contains much sand, and mushrooms (morels) grew abundantly. Walnut

was also exceedingly abundant on some of the floodplains rich in sandy or gravelly loams."

The types of variations in the swamp forest communities discussed above may be found within the limits of a single county. When observations are extended over a wider geographical range, variations resulting from the elimination of certain species are found. Such variations are illustrated in Ohio by the absence of hemlock, yellow birch, pine, and magnolia in the Black Swamp of northwestern Ohio, and by the absence of sweet gum and river birch in northern Ohio. When the area is extended to include the swamp forests of Kentucky and Arkansas, several other variations in floristic composition and in relative dominance are encountered.

FACTORS UNDERLYING THE RELATIVE ABUNDANCE OF SPECIES IN THE DIFFERENT SWAMP FOREST COMMUNITIES.

In the above topic attention was called to the increase in relative abundance of tulip and walnut upon sandy and gravelly loams and of pin and swamp white oak upon certain heavy clay soils. Earlier in the paper attention was called to the outstanding effects of moisture and soil aeration upon the habitat range of the various tree species in northern Ohio, and upon the order in which these trees invaded the swamp habitat. The effect of shade in habitats occupied by beech-maple is shown in the chart by the greater abundance of these species in habitats both too dry and too poorly drained for beech-maple. Similarly certain species of the swamp forest formation may overshade other swamp forest species and decrease their abundance in certain habitats.

While drainage conditions, soil aeration, and the complex of factors underlying geographical distribution may account for the presence or absence of a species in one or more of the communities that make up the successional series of the swamp forest formation in northern Ohio, the explanation of local variations in relative abundance of a species within a particular community, such as the red oak-linden transition, in which the given species normally grows must also take into account the influence of several other factors, such as biotic competition, pre occupation by approximately ecological equivalents, biotic history of the habitats, and time and rate of succession.

Soil types have been proposed as an explanation of the distribution and composition of plant communities. The study of the relations of vegetation types and soil types is a fruitful field of research, and soil maps are of great aid to the biologist in indicating where changes in vegetation types may be expected. The soil type as it is mapped, however, represents a complex of factors, and therefore may not be relied upon to delimit the particular factor or factors of most importance biologically. In previous reports* the writer called attention to the fact that the soil type alone may decidedly fail to account for either the composition or the distribution of plant communities. For example under natural conditions the plant communities of marsh and wet prairie, and the transitional phases and communities of the swamp forest formation occurred upon the same soil type—Clyde silty clay loam—within the limits of one county. Furthermore these different plant communities also occurred upon Newton clay loam, Newton silty clay loam, and most of them upon Brookston silty clay loam within the same county. It is obvious therefore that different vegetation types may occur upon the same soil type, and that the same vegetation type may occur upon several soil types. But if we study all of these relations between a certain vegetation type and several soil types, the particular factors in the soil that influence the vegetation type may become evident.

SECONDARY SWAMP FOREST COMMUNITIES.

Several factors determine the nature of secondary swamp forests. Secondary forests may be little different from the virgin forests. Many of the secondary swamp forests of northern Ohio are claimed by the early settlers to be good examples of what grew there originally. Again secondary forests may consist mainly of secondary species of the virgin forest either in pure or mixed stands. This last condition may occur following a single clearing, but it is more likely to occur following repeated clearings or when grazing or cultivation intervenes between clearing and reforestation. Attention should also be called to the fact that numerous areas in the state now

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*Sampson, H. C. Vegetation types and soil types of Marion County, Ohio. Ann. Assoc. Amer. Geog. 20: 40–41, 1930. Advantages and limitations of the use of the distribution of soil types as a basis of mapping the distribution of vegetation types. Proc. Ohio Acad. Sci. 40: 390–391, 1930.

occupied by secondary communities of swamp forest species were originally covered by beech-maple forests.

A comprehensive survey of secondary forests remains to be made. Attention, however, may be called to the relation of secondary swamp oak-hickory forests to the transitional phases of the swamp forest in northern Ohio. Beginning with the wettest phases of the elm-black-ash-soft maple community, the corresponding secondary swamp oak-hickory forest that may occur is given to the right in the following summary. The number of species of oak and hickory increases with each successive phase since species of the wetter phases still persist in the better drained phases.

Successional Phases of the Virgin Elm-Ash-Soft Maple Community:	Corresponding Secondary Swamp Oak-Hickory Forests:
1. Elm-Black Ash-Soft Maple Association.	Pin Oak-Swamp White Oak.
2. Bur Oak-Big Shellbark Hickory transition.	Bur Oak-Shellbark Hickory with Pin Oak, and Swamp White Oak.
3. Red Oak-Linden transition.	Red Oak-Hickory. Pin, Swamp White, Bur, and Yellow Oaks. Shellbark, Shagbark, and Bitternut Hickories.
4. Tulip-Walnut transition.	Similar to the one above.

The order of invasion of the swamp forest by beech and white oak is variable. Beech is usually first but not always. Beech is decidedly an earlier invader than hard maple. When a wet beech-maple forest is cleared the corresponding secondary oak-hickory forest which sometimes follows includes white oak in addition to the oaks listed above. The white oak-black oak hickory and the oak-chestnut-hickory association are characteristic of upland not of swamp habitats.

THE MIXED MESOPHYTIC FOREST COMMUNITY OF NORTHEASTERN OHIO.*

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Botanists and foresters working in the deciduous forest area of the Eastern United States frequently encounter mixed communities of mesophytic trees that cannot be readily classified by means of the binomial or trinomial terms in general use. Neither are these mixed communities the usual transitional zones dominated by the dominant species of the two "competing" associations. They are generally characterized by an unusual increase in abundance of several of the commonly occurring secondary species intermingled with the dominants of from two to three or more associations.

Griggs[1] called attention to the diversified forests of some of the coves of the Sugar Grove region of Ohio. Miss Braun[2] recognized a mixed mesophytic forest in the Cincinnati region. Frothingham, *et al*[3] described under the heading of "cove hardwood type," a mixed forest community in the Southern Appalachian Mountains. They report that this forest type in the Southern Appalachians occupies moist coves or ravines with their adjacent lower slopes, sometimes extending for some distance up protected slopes of north exposure. When Transeau first attempted to classify the forest communities in central and eastern Ohio he became convinced that it was necessary to recognize a mixed mesophytic forest community. He first called my attention to it in 1917. Since then we have seen numerous areas of it in Ohio and adjacent states. In a recent reconnaissance survey of the southern states Transeau[4] concluded

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*Papers from the Department of Botany, the Ohio State University, No. 263.

[1]Griggs, R. F. A botanical survey of the Sugar Grove region. Bull. No. 3, Ohio Biol. Survey, Page 273, 1914.

[2]Braun, E. Lucy. The physiographic ecology of the Cincinnati region. Bull. No. 7, Ohio Biol. Survey, 1916.

[3]Frothingham, *et al*. A forest type classification for the Southern Appalachian Mountains and the adjacent Plateau and Coastal Plain regions. Jour. Forestry 24: 673–684, 1926.

[4]Transeau, E. N. Vegetation types and insect devastation. Ecology 8: page 286, 1927.

that the mixed mesophytic forest of Ohio is a northward extension of the magnificent forests of the lower slopes of the Great Smokies and the dissected Allegheny plateau of eastern Tennessee.

The mixed mesophytic forest community has not been generally recognized as such, neither has it received a critical ecological analysis. Very little is known of the variants that will need to be recognized when it is studied throughout its entire geographical and altitudinal ranges. The conditions under which the mixed mesophytic forest develops in northeastern Ohio appear to be relatively simple. The data in this report are presented for what value they may have in the way of suggestions.

The accompanying chart (Chart I) showing the approximate habitat range of species occurring in the mixed mesophytic forest community of northeastern Ohio is sufficiently accurate in detail to show (1) the composition of the mixed mesophytic community, (2) that it is characterized by an increase in abundance of secondary species intermingled with the dominants of two or more associations, (3) that it appears to be a special type of transitional community occupying a position between dry sites covered by oak-chestnut and moist sites in which the complex of factors is favorable to the dominance of beech-maple, and (4) that there are sufficient differences in drought resistance of the species involved and the consequent order of their invasion of the oak-chestnut association with increasing moisture that considerable variation in the composition of the mixed mesophytic community may occur locally.

The chart is constructed on the same plan as the chart described in the previous paper on the swamp forest formation of northern Ohio, with the exception that the present chart shows the order of invasion of the oak-chestnut community by the trees found in the mixed mesophytic community. Owing to lack of space the names of the four forest communities of the swamp forest formation indicated in the chart were omitted. Reading from left to right they are the tulip-walnut, red oak-linden, bur oak-big shellbark hickory transitions of the elm-white ash-red maple community, and the elm-black ash-soft maple association described in the prvious paper. The two vertical broken lines in the chart enclosing a part of the oak-chestnut community and a part of the mixed mesophytic community were added to indicate an intermediate community

CHART I

Chart showing the approximate habitat range - horizontal lines - of trees occurring in the Mixed Mesophytic Community in northeastern Ohio. The relative abundance of each species when present is indicated by the following symbols: a = abundant, c = common, f = frequent, o = occasional, r = rare. The Mixed Mesophytic Community is limited to particular sites in which several secondary species become relatively abundant together with the dominant species of two or more associations.

Species	Oak-Chestnut Community	Mixed Mesophytic Community	Beech-Maple Association	Transitional phases of the Swamp Forest Formation
Quercus coccinea Scarlet Oak		r-o		
Quercus velutina Black Oak		r-f		
Quercus prinus Chestnut Oak		r-f		
Castanea dentata Chestnut		r-a	r-c	
Nyssa sylvatica Sour Gum		r-f	r	r-c
Acer rubrum Red Maple		f-a	r-c	f-a
Sassafras variifolia Sassafras		r-f		
Cornus florida Flowering Dogwood		o-f	r-f	o-f
Amelanchier canadensis Shad Bush		r-o		
Prunus virginiana Choke Cherry		r-o		
Carya microcarpa Little Bitternut Hickory				
Carya glabra Pignut Hickory		r-c	r-f	
Quercus alba White Oak		r-a	r-c	r-f
Quercus Muhlenbergii Yellow Oak		r-o	r-f	r-c
Carya alba Mockernut Hickory		r-f	r-f	
Prunus serotina Black Cherry		r-f	r-f	r-f
Fraxinus americana White Ash		r-a	r-c	r-a
Fraxinus lanceolata Green Ash		r-f	r-f	r-f
Ulmus fulva Red Elm		r-c	r-f	r-c
Carya ovata Shag-bark Hickory		o-f	o-c	f-a
Quercus rubra Red Oak		r-a	r-c	f-a
Carya cordiformis Bitternut Hickory		r-f	r-f	r-c
Juglans cinerea White Walnut		f-c	r-o	r-c
Juglans nigra Black Walnut		r-c	r-o	r-a
Magnolia acuminata Cucumber Tree		r-a	r-f	r-f
Liriodendron tulipifera Tulip Tree		f-a	r-c	r-a
Ostrya virginiana Hop Hornbeam		r-f	r-f	r-c
Morus rubra Red Mulberry		r-f	r-o	r-f
Carpinus caroliniana Blue Beech		r-f	r-f	f-c
Tilia americana Linden		r-c	r-c	r-a
Fagus grandifolia Beech		r-a	c-a	r-f
Acer saccharum Sugar Maple		r-a	f-a	
Acer nigrum Black Maple		r-a	f-a	
Ulmus americana American Elm		r-c	r-c	c-a
Tsuga canadensis Hemlock			r-c	r-a

which is variously referred to as oak-tulip, oak-chestnut-tulip, or dryer phase of the mixed mesophytic community depending upon variations in its composition, and also upon the different objectives an observer may have in making classifications of forest communities.

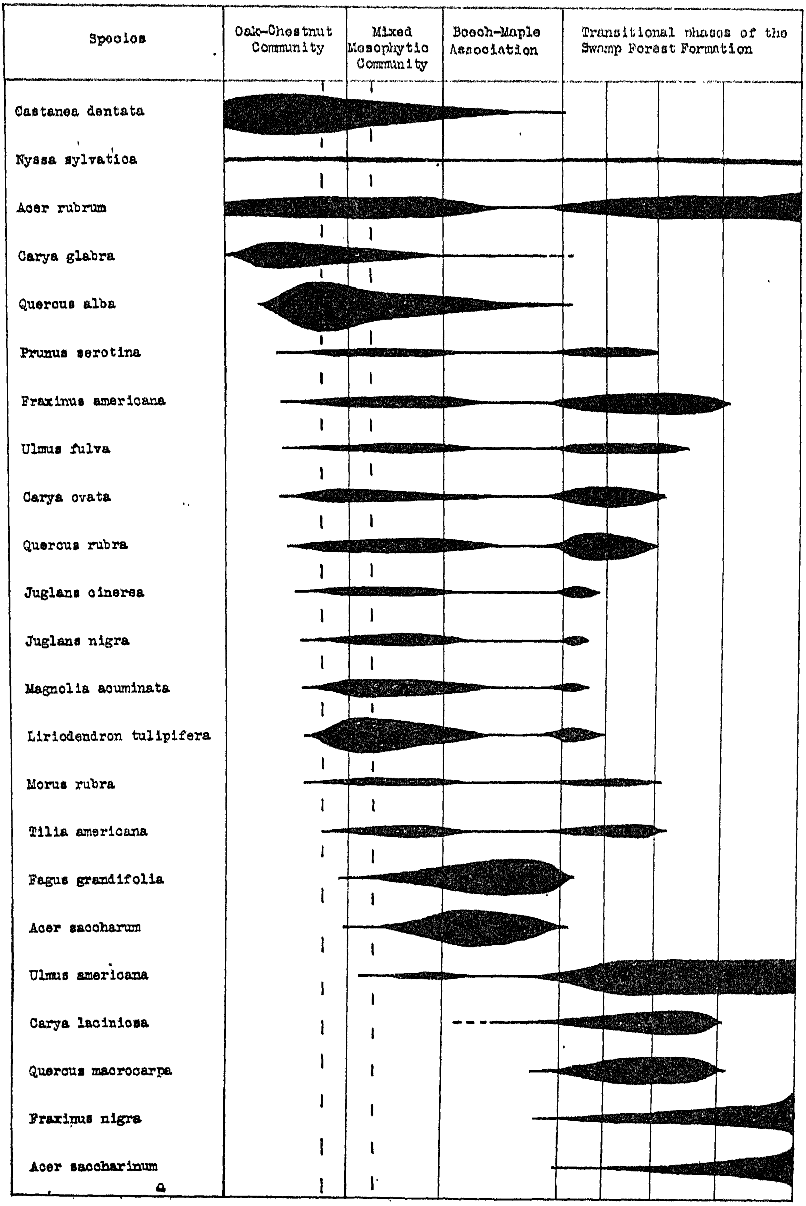
The first ten species listed at the top of the chart occur in the dryest oak-chestnut forests found in northeastern Ohio. An attempt was made to list the remaining species in the chart in the approximate order of their invasion of the oak-chestnut forest with increasing moisture. Major attention was given to the order of invasion of the oaks, hickories, tulip, magnolia, beech and hard maple. The number of observations made was not as large as desired, and perhaps the order of some of the species is incorrectly listed. Furthermore the order of invasion of some of the species is modified somewhat by the nature of the substratum, being different for sand, rock outcrops, and clay. The possibility of a few minor errors, however regretable, does not annul the major facts illustrated by the chart.

The chart shows the relative distribution of the species under the combined effects of all the factors of the natural habitat, primarily the combined effects of the moisture gradient, soil aeration, and shade. Wherever man interfers with the factors of "natural competition" the habitat range of a species often becomes extended.

The species frequently found occupying first place in the mixed mesophytic community of northeastern Ohio on the basis of number of individuals present are beech, sugar, black, and red maple, tulip, magnolia, chestnut, white and red oak, and white ash. Somewhat less abundant, but decidedly more abundant than they occur as secondary species in the beech-maple association are red elm, black and white walnut, linden, black cherry, sour gum, flowering dogwood, pignut, bitternut, shag-bark, and mocker nut hickories, red mulberry, and american elm. Chestnut oak and hemlock are of very local occurrence in northern Ohio. The mixed mesophytic community is referred to above as a special transitional phase with the distinction in mind that any transitional forest in which the dominants of the two "competing" associations remain dominants of the transition and the secondary species continue to remain subordinate should be referred to merely as a transition. For instance, an oak-chestnut beech-maple transition in which only oaks, chestnut, beech, and maple are the dominant trees.

CHART II

Chart showing where the maximum abundance of individuals of a species may occur in virgin plant communities of which the species is a member. The relative endurance of poor soil aeration, shade, and drought by the different species in the chart is exemplified. The data also illustrate transitional phases, and the dominance of beech and hard maple in certain habitats.



Attention is particularly called to the invasion of the oak-chestnut association with increasing moisture by such species as white and red oaks, magnolia, tulip, white and black walnut, mockernut, shagbark, and bitternut hickories, white and green ash, and cherry before the entrance of beech and hard maple. When several of these species become abundant it is necessary to recognize either an early dryer phase of the mixed mesophytic community or a luxuriant phase of the oak-tulip or the oak-chestnut-tulip community* in which beech and hard maple are either absent or appear only as scattered small undergrowth trees. With increasing moisture beech and hard maple through increase in size and abundance also assume the rank of dominants, though in the mixed mesophytic community they were apparently often overtopped by oaks, chestnut, tulip and magnolia.

In northeastern Ohio beech invades the oak-chestnut association earlier than hard maple. This fact appears to account for the absence in northeastern Ohio of the oak-maple community that is frequently found as one approaches an oak-hickory and prairie climate.

Other variants of the mixed mesophytic community include (1) local variation in the relative abundance of individual species such as tulip, magnolia, oaks, chestnut and walnut, and (2) elimination of species beyond their geographical range. As one crosses northern Ohio from east to west, hemlock, chestnut, and magnolia drop out. The mixed mesophytic community on limestone outcrops in northen Ohio differs from the one described in having a greater abundance of yellow oak and blue ash and no chestnut. Altitudinal and geographical variants throughout the entire range of the mixed mesophytic community have been but partially analysed at present.

A second chart (Chart II) showing where the maximum abundance of individuals of several tree species may be found in northern Ohio further emphasizes (1) the possibilities of transitional variants, (2) the dominance of beech and hard maple in certain habitats and (3) the similarity of the mixed mesophytic community and the mixed swamp forest transition that sometimes develops on areas slightly too poorly drained for the dominance of beech and maple as previously described for northern Ohio.†

*This community is indicated in the charts by the two vertical broken lines.

†Sampson, H. C. Succession in the Swamp Forest Formation in Northern Ohio. Ohio Jour. Science, 30: 340–357, 1930.

The secondary species of the beech-maple association in northern Ohio include all of the species listed for the mixed mesophytic community. But where the habitat conditions are most favorable for beech and maple their dominance is very effective, and the secondary species occur only as scattered and occasional trees. Attention is also called to the fact that certain species especially tulip, magnolia, the walnuts and hickories, red and yellow oak, cherry, linden, red elm, and white ash, endure slightly less drainage than beech and hard maple. Consequently they sometimes become abundant in the best drained phases of the swamp forest before conditions are favorable for the dominance of beech and hard maple. It appears, therefore, that but for the dominance of beech and hard maple, the mixed mesophytic forest community in northeastern Ohio might occupy a much larger portion of the area exhibiting the soil-moisture gradient within the range favorable to such species as tulip and magnolia.

Two questions, therefore, arise. What are the conditions that favor the dominance of beech-maple and restrict the mixed mesophytic community to certain local habitats in northeastern Ohio? Is the mixed transitional swamp forest that sometimes develops on areas not quite sufficiently drained for the dominance of beech and hard maple a phase of the mixed mesophytic community already described as a special transitional phase between oak-chestnut and beech-maple?

For an opinion on the last question reference should be made to the charts presented in this paper and to the chart in the earlier paper on the "Succession in the Swamp Forest Formation in Northern Ohio." On the basis of the data presented in the charts it is obvious that the mixed mesophytic community described above and the mixed transitional swamp forest community sufficiently drained for the entrance of tulip, magnolia, the walnuts, and frequent individuals of beech and hard maple have much in common. They differ primarily in three respects. First in their vegetational history. The one succeeds the elm-ash-soft maple community as the result of the filling and drainage of swamp habitats, while the successional relations of the other are associated with the beech-maple and oak-chestnut communities. Secondly they differ in the presence and absence of certain secondary species; the one having certain secondary species holding over from the oak-chestnut association, the other having certain secondary species holding over from the

elm-ash-soft maple association. In the third place there is a difference in the proportion of the principal species. For instance american elm, red oak, ash and linden are relatively more abundant in the mixed swamp forest transition, while such species as white oak, chestnut oak, and chestnut are rare or entirely absent. Perhaps one may be regarded as a wetter phase, the other as a somewhat dryer phase of the mixed mesophytic community. If they may be so regarded it follows that the mixed mesophytic community in northeastern Ohio has a somewhat wider soil-moisture gradient than beech-maple and is eliminated from the middle portion of this range wherever edaphic conditions are most favorable to the dominance of beech-maple.

The habitats in which the mixed mesophytic community occurs in northeastern Ohio appear to have certain conditions in common, but these conditions may not hold throughout its entire geographical range since the influence of Lake Erie may be a factor and still other factors may become more prominent elsewhere.

Northeastern Ohio includes a portion of the glaciated area of the Allegheny plateau. The streams are relatively young with narrow flood plains and medium sized valleys 100 to 200 feet below the level of the surrounding country. The climate is sufficiently moist for the beech-maple forest through out the entire range in altitude from about 580 feet near Lake Erie to about 1200 feet on the divide between the Lake Erie and Ohio River systems in Portage and Trumbull Counties. Owing to differences in physiography and soils numerous local areas are not covered by a beech-maple forest but are occupied by relict bogs, conifer bog forests, swamp forests, beech-maple-birch-hemlock forests of gorges and deep valleys, oak-chestnut, and mixed mesophytic communities. The most extensive development of the last two communities named above occur on the gravelly hills of the interlobate moraine and the slopes of the Cuyahoga River from near Burton in Geauga County southward beyond Massillon in Stark County.

The mixed mesophytic community occurs at all altitudes from that of the old lake bed near Lake Erie to the top of the divide. Its restriction to local habitats in northeastern Ohio appears therefore to be due entirley to edaphic conditions, local exposure, and the supreme dominance of beech-maple in

certain habitats. The local habitats in which it is found may be summarized as follows:

1. Slopes of valleys in which the soil is a mixture of decaying rock fragments, loose soil, and humus. Narrow belts occur at various places on slopes of several valleys where the succession with accompanying physiographic changes may be (1) beech-maple on upland ⟶ mixed mesophytic on slope ⟶ beech-maple on flood plain, or (2) beech-maple on upland ⟶ oak-chestnut on ledge ⟶ mixed mesophytic on slope ⟶ beech-maple on flood plain. Similar slopes physiographically but with heavy soils with poor internal drainage are covered by beech-maple.

2. Slopes of hills of the interlobate moraine where the successional relations are oak-chestnut ⟷ mixed mesophytic ⟷ beech-maple depending upon whether the change is from dry to moist conditions or the reverse.

3. Four exceptions to slope habitats were found: (1) gravel-rich swales between hills of the interlobate moraine with sufficient drainage to exclude lake and bog formation, (2) occasional high terraces between slopes covered with mixed mesophytic forest, (3) low sand ridges on swamp forest areas on the old lake beds, and (4) similar low ridges of sandy loam on top of a wet flat upland near to the top of the divide in Trumbull County.

All of the above habitats occupied by the mixed mesophytic community, therefore, appear to be alike in having soils with a good supply of water and at the same time with good internal drainage. Slopes with heavier soils and poorer internal drainages are covered by beech-maple. The dryest habitats are covered by oak-chestnut. Certain rocky slopes with numerous irregularities in depth of soil are also favorable sites for mixed forests.

The soil types that appear most favorable to the development of the mixed mesophytic community in northeastern Ohio are certain areas of Wooster loam and gravelly loam, Volusia loam, and Dunkirk sand, but other forest associations are also found on these soil types. The location of the soil types named above was obtained from published maps. Attention should also be called to the fact that the soil survey of this area was made before the methods of soil survey reached their present state of development. Apparently modern soil surveys

will be more helpful in detecting some of the important edaphic conditions that become controlling factors over local areas.

Secondary associations that follow the cutting of a mixed mesophytic forest community are dependent not only on the varied methods of cutting and the subsequent activities of man on the area but also upon the composition and phase of development of the community that is cleared. The community may reproduce itself with but slight variations from the original, but there is usually a noticeable change in composition. On the dryer sites oaks, chestnut and hickories often become the most abundant trees. On moist sites cherry, ash, elm, tulip, walnuts, red oak, and maple may become the most abundant species. On favorable sites beech and hard maple increase in abundance in secondary forests following selective cutting of oaks, chestnuts, tulip, and magnolia in mixed mesophytic forests.

ANOMALOUS POST CAVAL VEINS IN A CAT.

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ABSTRACT—"*Anomalous Post Caval Veins in a Cat.*" A description is presented of an adult Cat with paired Post Caval Veins, Vena Cava Posterior or Inferior. These extend, without any other anastomosis, anteriorly, to a point between the two kidneys, and from there continue as one vessel. This point of fusion is three and one-half inches anterior to the usual junction of the leg vein, Iliacs. The left ovarian vein joins the left one of the Post Cavæ at a level posterior to the kidney of that side, instead of being a continuation of the left renal vein. The Ureters extend from a dorso-lateral to a ventro-lateral position between the paired Post Caval veins. This blood vessel pattern is interpreted as the "AD" type of Huntington and McClure, the main feature of which is the persistence of embryonic Post Cardinal veins. A labeled photograph accompanies this described variation.

Unusual blood vessels, representing persistent embryonic channels, have received special study in recent years. However, Reagan, in a recent review, ('29), has shown that not merely in our time, but at intervals during the last century, important discoveries and interpretations have been made on the eutherian vena cava. Paired post caval veins, (vena cava posterior or inferior) have been observed in several patterns as related to the aorta and ureters. From their own researches, and observations of other anatomists, Huntington and McClure ('07, '20, and '29) list seventeen possible vascular anomalies of this part of the body in mammals. Darrah ('07) found one particular anomaly in twenty out of 605 cats. All of these had paired caval veins, but six of them did not continue the common Iliac trunks on anteriorly to the kidney region without anastomoses. According to Huntington and McClure ('29), their figure 25 shows the only case of this pattern of blood vessels that has been reported for man. That case was in a fetus (from Gladstone, '12, Figure 8).

An atypical arrangement of the veins, arteries and ureters has recently been found in the Comparative Anatomy Laboratory at the University of Illinois, Urbana. From a group of five doubly injected and embalmed cats, one adult female was found with long paired post caval veins. The blood channels from the posterior limbs, the iliac veins, do not fuse until they reach a point between the two kidneys. This place of union

is three and one-half inches anterior to the usual junction. The ureters arise dorso-lateral to, and pass between the caval veins to a ventro-lateral position. Also, the left sex vein, (ovarian vein), joins the left one of the paired post cava somewhat posterior to the level of the kidney. The veins extend laterally, along with the corresponding arteries, but their origin is posterior to that of the arteries. Otherwise, the cat appeared normal.

The research of Huntington and McClure, especially, provides a rather clear-cut explanation, as far as it goes. The capillary plexus on the venous side has been found by these authors, and others, particularly for the cat and human to early develop into paired longitudinal veins of a variable extent and duration. Figure one of their memoir, '29, is a "composite diagram of embryonic veins of the domestic cat (Felis domestica) based on a detailed study of the development of the veins." A similar figure appears in their paper of '20. One pair of these longitudinal embryonic channels is known as the post cardinal pair. Ventromedially to these are the subcardinal vessels. Dorsomedially to the post cardinals are the paired supracardinals. By the dropping out of certain ones of these, or parts of a given one, the persistence of others, and connections with a venous ring in the region of the kidneys the different atypical conditions are accounted for.

This unusual, but apparently functionally normal condition is placed under the "AD" type of Huntington and McClure, '29. It represents the persistence of both posterior cardinal veins of the embryo, instead of the right supracardinal vein, which forms the normal vena cava posterior (inferior) of the cat and man. Apparently this specimen closely resembles one of the Darrah series of cats, that one illustrated by Huntington and McClure, '29, figure 20, in diagnostic characteristics. That this is the "AD" type is evident from the position of the Ureters with reference to the caval blood vessels, and further by the sex vein connection. This latter is interpreted to represent a part of the right and left subcardinal channel. The developmental history of these veins may not be so simple as here postulated. Reagan, '29, page 208, closes his reveiw of the literature on this subject by stating that, "The formation of the vena cava is a much more complicated process than any existing account would indicate."

However, these observations record another atypically paired vena cava posterior (post cava), and refer to the pair, tentatively, as persistent embryonic post cardinal veins. The cat is preserved at the University of Illinois. Figure one is a labeled photograph of this variation.

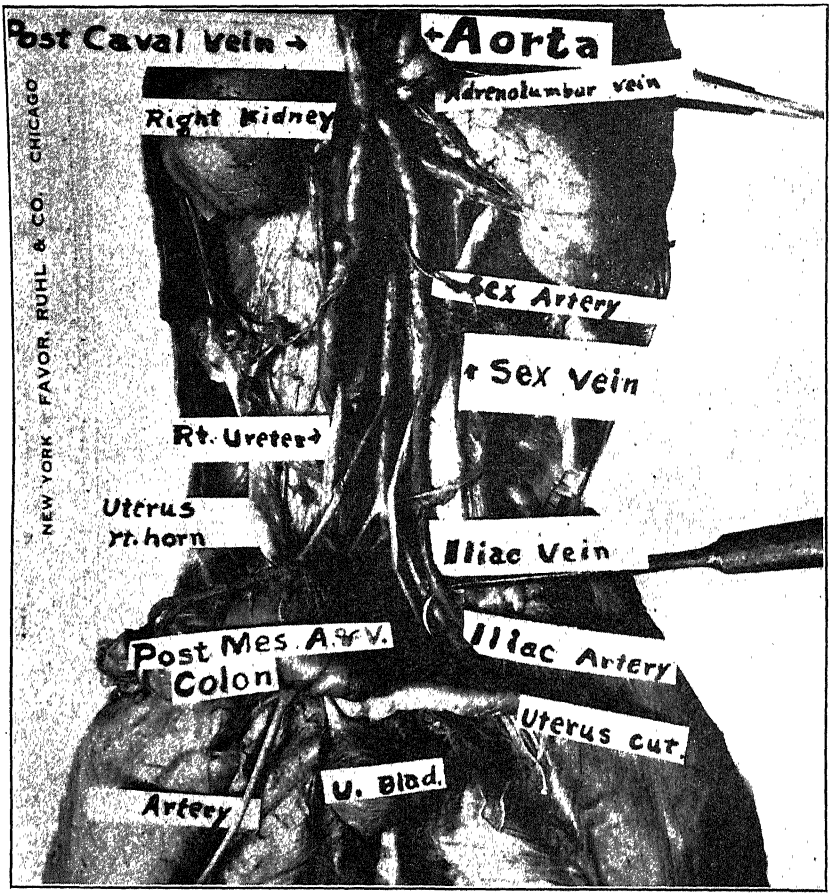

FIG. 1. CAT—Type "AD" Post Cava (Vena Cava Posterior), showing persistent embryonic post cardinal veins.

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COAL RESEARCH LABORATORY

A recent announcement through the *News Service* of the Carnegie Institute of Technology that will interest many of our readers, states that:

"Gifts totalling $425,000 to extend over a five-year period for the establishment and maintenance of a coal research laboratory at the Carnegie Institute of Technology were announced yesterday by Dr. Thomas S. Baker, president of the institution.

"The Buhl Foundation, of Pittsburgh, is the largest single donor to the project, contributing $50,000 at the outset for the equipment of the laboratory, and $25,000 a year for five years for a program of pure research. The gift of the Buhl Foundation is made with the stipulation that certain additional amounts shall be secured from other sources. This condition has now been met through the co-operation of six great American concerns who are the other contributors to the project that has been outlined by Dr. Baker. The firms co-operating are the United States Steel Corporation, the General Electric Company, the Koppers Company, the New York Edison Company, the Standard Oil Company of New Jersey, and the Westinghouse Electric and Manufacturing Company. These six corporations will contribute a total of $50,000 a year for five years for the maintenance of the laboratory.

"The laboratory, according to Dr. Baker, will be a part of the Carnegie Institute of Technology, and will undertake fundamental research in coal and the products which may be obtained from it. The Carnegie Institute of Technology will organize graduate courses for the training of students in fuel technology in connection with the research laboratory, with the research staff giving instruction.

"Mr. Myron C. Taylor, chairman of the Finance Committee of the U. S. Steel Corporation, has co-operated with Dr. Baker in outlining the plans for the research laboratory that will be unique in America. It was largely through the endeavors of Mr. Taylor that the financial aid of the industrial concerns was secured.

"Mr. Charles F. Lewis, director of the Buhl Foundation, in commenting on the laboratory that the organization which he heads has made possible, said:

" 'It is gratifying to the Buhl Foundation that to its grant have been joined sufficient additional funds to assure establishment at the Carnegie Institute of Technology of a modern laboratory for prosecution of a vigorous program of pure research in coal. Two international conferences under President Baker's direction have prepared the way for this program and give assurance that it will

have the cordial and sympathetic interest of outstanding men of science throughout the world. The probability that the laboratory may make important contributions to basic scientific knowledge is strengthened by this relationship.

" 'The Institute's research program is, moreover, of distinct economic importance to the Pittsburgh district. The development in Pittsburgh of knowledge of coal, linked with additional provisions for training here expert technicians, may confidently be expected to have important consequences not only for this basic industry and for those employed in it, but for the people generally.'

"Dr. Baker has long been interested in the study of coal and the use of its products. He was the organizer of the First and Second International Conferences on Bituminous Coal that attracted famous scientists from abroad, and drew the attention of the world to Pittsburgh. A third conference will be held in Pittsburgh at the Carnegie Institute of Technology in November, 1931.

"Dr. Baker in speaking of the research laboratory for which he has worked for several years, said:

" 'Pittsburgh is the appropriate place in which to study coal. Its industria greatness is based largely on the rich supply of fuel in this district. Its future is somewhat endangered by the unsatisfactory condition of the coal industry. It would be too much to say that science can cure all the ills of this phase of our business life, but research offers the best opportunity for solving many of its baffling problems. We are in the center of the greatest coal field and the greatest coal market in the world. It is important that the people of this district should have near at hand the best scientific resources that can be secured in the world to aid them in dealing with what is most vital to the welfare and progress of our community.

" 'Coal touches almost every phase of modern life. As far as we can see it will always be the chief source of power, and cheap power is an essential to human welfare in our present civilization. It is the source of many of the necessities of life.

" 'There is no laboratory at present in the United States that is doing the work that we have outlined. There are many uses and by-products of coal still to be developed. Finally, there is the question of the smokeless city which can never be answered until a serviceable smokeless fuel has been discovered.' "

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PREGLACIAL, INTERGLACIAL AND POSTGLACIAL CHANGES OF DRAINAGE IN NORTHEASTERN OHIO WITH SPECIAL REFERENCE TO THE UPPER MUSKINGUM DRAINAGE BASIN.*

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The advance of the ice brought about many changes of drainage and this seems to be especially applicable to the State of Ohio, where so many streams are running either in new channels or the direction of flow has been reversed. Many of these changes have already been explained but there is still much work to be done before a complete and satisfactory explanation of some of these problems can be presented.

My personal interest in these questions was aroused by observations made during the progress of the Reconnaissance Soil Survey of Ohio and attention was called to a few of these in a brief article in the October 23, 1914 issue of *Science*. Absence from the state for several years and the taking up of other work since my return has not permitted the following up of those suggestions as I had planned to do. Killbuck Creek, which rises north of Wooster and flows southward, offers one of the most puzzling problems of any of the streams and I have been especially interested in trying to find a satisfactory solution of the drainage in this particular section, since there is now available in the numerous borings for oil and gas positive evidence that its deep channel was not made by a stream flowing northeastward toward Orrville as suggested by Todd.† This study, however, has necessarily led me to consider, in a limited way at least, this entire section of Ohio and to some

*Paper read before the Geological section of The Ohio Academy of Science at Columbus, Ohio, April 19, 1930.

†Todd, J. H., Ohio Academy of Science, Special Papers No. 3, 1900, page 52.

extent the entire State. The subject is so large that I can only hope to offer a few suggestions, which I trust may be of help to others in the solution of these drainage problems.

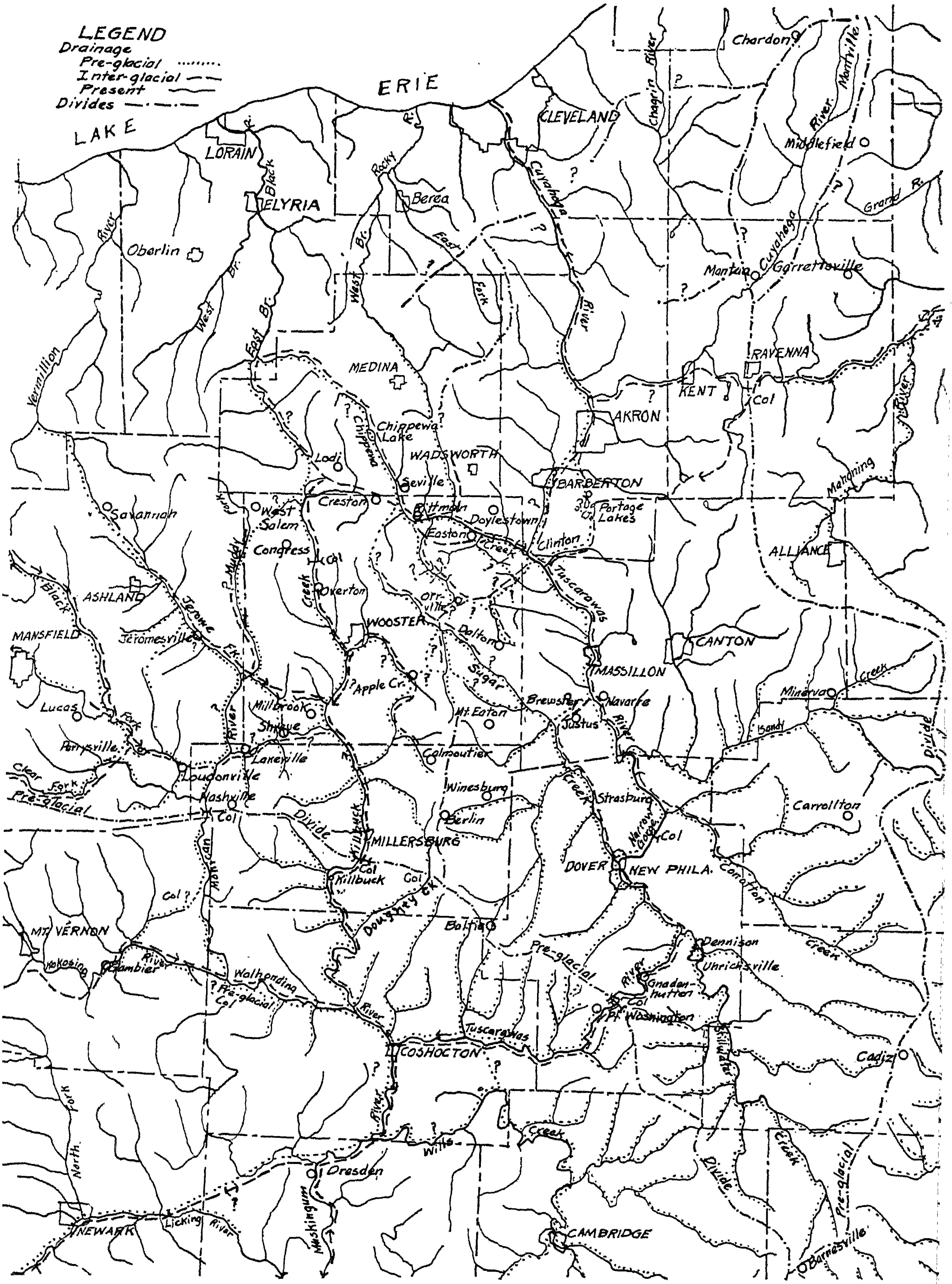
Importance of Interglacial Erosion.

In the article in *Science*, referred to above, attention was called "to the probable interglacial rather than preglacial origin of many old valleys in Ohio." Further study has tended to confirm this suggestion and, in fact, has led to the conclusion that *practically all of the deep valleys in this northeast section of the state, and probably in other sections as well, are of interglacial or postglacial rather than preglacial origin.* In other words the western extension of the plateau into Ohio had, before the beginning of the ice age, been reduced to a peneplain and the fairly stable conditions then existing were disturbed by the first advance of the ice and each successive advance caused further disturbances and changes in the drainage and resulted in rejuvenating the forces of erosion and the carving out of deeper valleys, which in many places, show little or no relation to those which existed in preglacial time.

If this suggestion represents a true interpretation of the preglacial conditions and the results brought about by the coming of the ice then it necessarily follows that it will be extremely difficult in many sections, and especially where radical changes in the drainage took place, to determine the exact location and direction of the preglacial streams. There are, however, some facts obtainable which will aid us in our investigation of this subject.

General Elevation and Slope of Uplands.

Perhaps the most important factors, which should be considered, are, (1) the general elevation and slope of the uplands, (2) the location of the main divides, valleys and streams and (3) the angle at which the tributaries enter the present stream channels, particularly in those sections where the streams were least disturbed by the ice. Topographic sheets, covering this section of the state, are now available from which it is possible to know the elevation in every part of the area. An examination of these topographic sheets shows that a very large percentage of the country lies at an elevation of from 1100 to 1300 feet. A few high points rise above 1400 feet and some of



Map of Preglacial, Interglacial and Postglacial Drainage in the Upper Muskingum Basin.

the valleys fall below 800. Nearly all of the country below 1100 feet in elevation is in the more important valleys or on the immediately adjoining slopes. The so nearly uniform height of the uplands is very strong evidence that the country was reduced to a peneplain with a surface sloping gently from the higher divides toward the broad valleys. If we can locate these old divides and valleys we will have made some definite progress in our determination of the preglacial drainage.

LOCATION OF PRINCIPAL DIVIDES.*

Geologists are pretty generally agreed that there was a preglacial divide on the present Ohio River between New Martinsville, West Virginia and Sardis in southeastern Monroe County, Ohio. From this divide the drainage was northward through the Grand River Valley to the Lake Erie basin and southward into the old Kanawha River. From the Ohio River the divide, forming the western boundary of the old Grand River drainage basin, extended northwestward to Woodsfield, thence almost directly north by Barnesville and Cadiz, passing southwest of Alliance, thence north by Ravenna, beyond which its course is somewhat uncertain as the original divide may have turned a little northeast to Middlefield, Huntsburg and Thompson or have run more nearly north near Mantua, Auburn Center and Chardon to Thompson.

The crest of this divide from near the Ohio at New Martinsville to south of Alliance is everywhere above 1200 feet and much of it is more than 1300 feet. From Alliance northward to beyond Ravenna none of it is above 1300 feet while a considerable part is between 1100 and 1200 feet. The lowest point is just south of Ravenna where it falls a little under 1100 feet, although in the valleys between Garretsville and Mantua and Parkman and Hiram Rapids the elevation is only slightly above 1120 feet. In general the elevation from Ravenna increases northward until several points again rise above 1300 feet.

*In the presentation of this paper topographic sheets, covering almost the entire area, were used and the location of the divides was brought out by coloring the areas above the 1300 foot contour line blue and those between the 1200 and 1300 foot contours red, but it is not practicable to publish these sheets in connection with this article. The accompanying map shows the present drainage and probable location of some of the preglacial and interglacial streams, divides and cols and will be of assistance in understanding the paper, although the reason for some preglacial and interglacial stream locations can only be seen by a detailed study of the topographic sheets.

From the above divide there branches off near Barnesville another one, which runs northwest to the Tuscarawas River between Port Washington and Gnadenhutten, where it is cut through by this stream; thence continues on northwestward by Baltic beyond which it divides, the main branch apparently extending westward across Doughty Creek at Troyer's Mill and is intersected between Millersburg and Killbuck by Killbuck Creek; thence continues westward south of Nashville, crossing the gorge cut by the Mohican River and following fairly closely the northern boundary of Knox County but turning a little more northwest to the plains between Mt. Gilead and Galion.

Most of the crest of this divide rises above 1200 feet and the portion south and west of Nashville often attains an elevation of 1300 feet and sometimes more than 1400 feet. A few points near Baltic and also toward Barnesville are above 1300 feet but most of the country bordering the Killbuck Valley is below 1200 feet although there are a few points less than a mile from the stream which rise above this elevation.

The other branch of this divide turns northward by Berlin to Calamoutier, where the elevation is more than 1300 feet and there are also points southwest and northeast of Winesburgh and south of Mt. Eaton which rise above this height. From Calamoutier a more or less dissected area extends northeastward almost to Dalton, beyond which its extension is uncertain for reasons which will be brought out later. The line of hills running northward from Doylestown and spreading out into a high plateau between Wadsworth, Medina and North Royalton and rising to more than 1300 feet at West Richfield and a few other points may represent its northern extension at some earlier time.

From Calamoutier the present divide turns northwestward by Weilersville, about half way between Wooster and Orrville, but the old divide may have branched off near Mt. Hope and run southwest of Fredericksburg and west of Apple Creek to Weilersville. From here it turned more to the northwest, crossed the Killbuck near Armstrong and at present swings on westward by Savannah, north of Shelby and then on southwestward and joins the highlands east of Galion. If the suggestions made in this paper are true the portion from Wayne County westward does not represent a preglacial divide but rather an escarpment, which was changed into a divide by the ice.

The evidence from the general level of the uplands seems to show that the portion of Ohio now drained by the upper branches of the Tuscarawas, Cuyahoga, Killbuck and Mohican represents an area with most of the higher portions on the south, east and north and a gentle slope from these directions toward the center and west. Differences in the hardness and dip of the rocks seems to have been the main factor in determining the general level of the uplands. *The general direction of the preglacial streams was from the southeast northwestward toward the broad plains to the west rather than from the edge of the plains southeastward into the hills as so many of them do at the present time. The former would certainly seem to be a more natural development than the latter.* If the preglacial topography was that of a peneplain, with most of the country still above an elevation of 1100 feet, such a system of drainage could have existed. This would mean that the present valleys have been very largely carved out since the coming of the ice, which hypothesis is supported by the steep slopes along nearly all the principle streams and the general youthful appearance of much of the topography and especially by the evidence of a preglacial col on the Tuscarawas near Port Washington, on the Killbuck south of Millersburg and the Mohican near its entrance into Knox County.

Probable Preglacial Drainage.

The section of the area not covered by the ice should furnish the most positive evidence of preglacial drainage as shown by the streams. There seems to be no reason to doubt that Conotton and Stillwater creeks, which rise in northwestern Belmont and eastern Harrison counties and flow northwestward to join the Tuscarawas, represent streams whose direction and location are the same as in preglacial time and that they formerly flowed on northwestward, the latter along the present channel of the Tuscarawas River and Sugar Creek, at least as far as Brewster, and the former along the present channel of the Tuscarawas, at least as far as Navarre. The old Stillwater may have turned northeastward by Justus and joined the old Conotton, flowing northward along the present Tuscarawas or the Stillwater, at least may have flowed northwestward across Wayne County to the present Chippewa Valley or more nearly westward by Kidron and Apple Creek to the Killbuck drainage. If one or both flowed northward by Massillon they may have

turned westward along the Chippewa valley or continued northward to the Cuyahoga. The southwestward course of the upper Cuyahoga and the southeastward direction of many of the tributaries of the Cuyahoga beyond Akron, as well as its failure to develop a broad valley like the Grand River, raise a question as to the Cuyahoga outlet as the earliest development of the drainage. On the other hand there seems to have been an old plain several miles in width developed along the Cuyahoga with an elevation around 1000 to 1100 feet, which seems to have been later cut into by the Cuyahoga, forming its present narrow gorge-like valley. The relatively small basin drained, as compared with the Grand River, might explain why the valley was not cut out wider and that of the present Upper Cuyahoga is probably a later glacial development.

The old divide may have extended northward from Dalton to Doylestown and the break through this west of Clinton may not have occurred until the first advance of the ice. The dip in the general level of the uplands from Medina southward and the rise again beyond Ashland seems to indicate that the drainage of a considerable area was toward the northwest along the Chippewa Valley either by Chippewa Lake or Lodi or both. The tributaries on the south side of the Chippewa Valley, as well as some other valleys in this section, practically all flow northward while those on the north side flow almost exactly in the opposite direction and it may be that the River Styx valley, Chippewa Lake and Lodi each represent separate preglacial channels which were connected together when the Grand River drainage flowed westward by Ravenna as will be explained later.

The angle at which the smaller streams enter the Tuscarawas Valley above and below Port Washington as well as an elevation of more than 1200 feet on the immediately adjoining uplands, as already pointed out, furnish very strong, if not conclusive, evidence of the existence of a preglacial divide between Port Washington and Gnadenhuten. The existence of such a divide at this point together with the narrow gorge east of Canal Dover would be absolute proof that the deepest erosion in the Tuscarawas and associated valleys took place during interglacial rather than preglacial or postglacial time and apparently at neither the first or the last advance. From this old divide the drainage was westward toward Coschocton and from there possibly westward along the Walhonding and Kokosing but

more probably along the old channel by Newark. The Kokosing and Walhonding valleys are evidently older than the Mohican, which was probably not formed until the last advance of the ice.

. The Killbuck drainage is difficult to determine, as probably most of its channel has been made since the first coming of the ice. The angle of its tributaries, as well as the elevation of the uplands, seems to show the presence of an old divide south of Millersburg from which the drainage was northward at least as far as Kauke and might have flowed on by Wooster, Apple Creek and Orrville as suggested by Conrey* to the Chippewa Valley but the direction of the tributaries around and beyond Wooster as well as the unnatural turning back towards the hills seems to be against this course. The former channel through the hills to Orrville as suggested by Todd must be abandoned as data from numerous wells and ravines show this to have been impossible. The more probable channel seems to be northwestward by Millbrook and along Jerome Fork of the Mohican by Ashland and Savannah, or possibly by the Muddy Fork through the old valley, which Conrey found east of West Salem, into the valley at Lodi.

The Black Fork of the Mohican is also believed to have flowed northwest and apparently also carried the waters of Clear Creek. The drainage from Loudonville was apparently eastward to Lakeville and thence northward into the Killbuck drainage but from Loudonville westward to Perrysville was probably into Black Fork. The Mansfield drainage is also thought to have been northwestward toward Shelby. The valley, which is followed by the Pennsylvania Railroad from Mansfield to Shreve, is probably mostly of interglacial rather than preglacial origin and apparently formed the principal line of drainage for this section at the time when the valleys were being cut deepest.

The Coming of the Ice.

The advance of the ice was from the northeast along the Lake Erie basin from which it spread southward, the tendency being to flow around the higher parts of the country and spread out like fans from the larger valleys. When the ice advanced far

*Conrey, G. W., Geological Survey of Ohio, Fourth Series Bulletin No. 24, page 20.

enough southward to encounter the northern end of the divide, forming the western boundary of the Grand River basin, it blocked the northward drainage and formed a large lake extending many miles southward. This lake continued to rise until it reached the level of the lowest point in this divide, which we have already seen is just south of Ravenna. In the article referred to in *Science* it was suggested that the Pittsburg drainage first broke over at this point and that the overflow at New Martinsville was at the time of one of the later glaciations. Leverett* gives a well record at Campbellport about two miles southeast of Ravenna, which with a head of 983 feet, failed to reach rock at 230 feet, or an elevation of 753 feet above sea level. Prof. G. F. Lamb of Mt. Union College in private correspondence informs me that he has traced this old valley southwestward by Fritch Lake to the Portage Lakes. Recent well records, obtained from the Kemrow Company, show depths of 400, 404, 407 and 499 feet to rock in Sections 7 and 18 just east or south of Mud Lake, which means that the old valley floor is here around 600 feet above sea level, or little if any above the present level of Lake Erie. Another possibility was from Campbellsport somewhat northwestward along Congress Lake outlet to the Cuyahoga. From Portage Lakes an old valley extends both north and south, in fact there seems to be a network of these old valleys in the section between here and Akron, Barberton, Clinton and Canal Fulton. One of these along Nimisila Creek apparently carried the Pittsburg drainage during the earlier advances of the ice, as the narrow gorge-like valley of the Ohio seems to indicate that the present channel of this stream was not formed until later glacial time.

As the ice advanced farther west and south it blocked the drainage of other streams, which drained the plateau to the northwest, although it seems probable that the waters, which flowed across the divide near Ravenna, followed the present Chippewa valley westward by Creston and Lodi until the ice moved far enough south to force them to seek another outlet. Whether this was at the first advance of the ice has not been determined but as soon as it happened the waters from the streams coming from the southeast were dammed up and broke over the old divide on the Tuscarawas near Port Washington and flowed southwestward by Coschocton and Newark and

*Leverett, Frank Mon. XLI, U. S. G. S., page 462, 1900.

joined those from the old Kanawha, although it is possible that the first break over was along the line of the Killbuck, which might have carried the Ohio drainage until it was forced farther to the southeast.

The northwesterly flow of other streams, which drained the old plateau, were also blocked and forced to seek a way around the ice, which was found by breaking over the old divide south of Millersburg, joining the Tuscarawas at Coschocton. This Killbuck drainage seems never to have again been northward, although the Old Grand River plain was so low that the Ohio drainage probably returned to its former channel after the retreat of the ice and continued northward during one or more interglacial periods. There is also evidence for thinking that the Tuscarawas likewise drained northward by Akron into the Cuyahoga during an early interglacial period and, in fact, may have furnished an outlet for the Kanawha drainage along the old valley from Circleville northeastward by Newark to the Tuscarawas at Coschocton and then along the line of this stream and the Cuyahoga to the Lake Erie basin at Cleveland.

The Scioto valley above Portsmouth is relatively much wider than the Ohio valley below this point. The elevation of the old Kanahwa valley, whose floor is about 100 feet above the present Scioto, where it joins it at Waverly, shows that the Scioto could not have been of preglacial origin. Some obstruction may have caused the Kanahwa to break over a low divide between Portsmouth and Sciotoville so that it flowed northward along the Scioto and joined the Tuscarawas as suggested above, during the interglacial period in which the deep valleys were formed. Only by a careful study of well records will it be possible to determine the slope of the rock floor of this old Scioto-Tuscarawas-Cuyahoga Valley and it may be that it was reversed in part of its course during different interglacial periods.

Deep Valleys of Interglacial Origin.

The old Tuscarawas-Cuyahoga valley was apparently from 250 to 500 feet deeper than at the present time and this depth enabled the tributary streams like the Kokosing, the Killbuck, which then carried the Mohican, and the Chippewa to cut out deep channels also. At Cleveland the rock floor is about 500 feet below the present valley, or less than 100 feet above sea level. East of the Portage Lakes it is around 600 feet

and would probably be lower in the center of the Lakes. A well record southeast of Easton in Section 21 Chippewa Township, Wayne County, struck rock at 443 feet and another one near the same place in the northeast quarter of Section 20 entered rock at 417 feet. The elevation of the present valley here is about 950 feet so the rock floor is apparently below the present level of Lake Erie. Further west in the Southwest quarter of Section 14 Milton Township the depth was 275 feet and in the southeast corner of Section 5 of the same Township it was 262 feet. Mr. Cummings of The East Ohio Gas Company states that he drilled a well near Strassburg in Tuscarawas County 400 feet before he struck rock. Leverett reports about 250 feet or more to rock at Newark and records in Killbuck valley south of Wooster in the middle part of the northwest quarter of Section 21, Township 15, Range 13, show 206 feet although other wells only a short distance away show 82,110, 126 and 142 feet to rock. As the present Killbuck valley is around 850 feet, while Orrville is 150 feet or more above it, the valley at Orrville would have had to have been more than 350 feet deep to have received the Killbuck drainage. While wells were found east of Wooster in Section 7, Township 16, Range 12 which had depths of as much as 227 and 240 feet the surface elevation at their heads would still make the rock floor as much as 100 feet above that of the Killbuck while almost immediately east in the same sections the depth was 44, 118, 120, 160 and in Section 8 only 42 and 90. Records in Sections 3 and 4, Lawrence Township, Stark County gave 248, 260, 265 and 277 feet. A well in Section 32, Prairie Township, Holmes County, showed 298 feet but it is apparently on a gravel terrace to the west of the present valley.

It is not possible in this paper to go into any further discussion of these old valleys, which were carved out to such unusual depths, apparently during some interglacial period. The evidence given seems sufficient to show that Killbuck valley was cut out by a stream flowing southward when the Tuscarawas at Coschocton was probably 250 feet or more below its present level and not by a northeastward stream.

Drainage Changes During Late Glaciation.

The drainage, which existed when these old valleys were formed, was disturbed by another advance of the ice, probably either the Illinoisan or the Wisconsin. If the former extended

as far toward the southeast as indicated by Leverett then the change of the Ohio, Muskingum and Licking to their present channels must have resulted not later than that advance. The Wisconsin glaciation went far enough southeast to cause the drainage of the upper Mohican, which formerly flowed eastward by Big Prairie and probably Shreve to the Killbuck, to cut a gorge through the hills south of Loudenville to the Walhonding, Clear Creek being forced to abandon its course by Perryville and break through the hills to join the Mohican. By climbing the hills east of Beach City this glaciation was also probably responsible for the Tuscarawas breaking through the hills east of Dover, where it runs through a gorge across the old ridge separating the old Conotton and Stillwater valleys. The narrowness of this gorge, as compared with the width of the valleys which it connects, is one of the most striking evidences of the long period of time which passed between its formation and the breaking through the old divide near Port Washington.

Whichever advance of the ice blocked both the northern and southern flow of drainage along this old Scioto-Tuscarawas-Cuyahoga valley, forcing a new outlet through the hills along the present course of the Muskingum, with a channel much above that of the old valley, caused a damming of the streams, a filling of the valleys and the bringing about of sluggish drainage in streams like the Killbuck.

Many other interesting possibilities and details might be pointed out, if space permitted. While some of the suggestions offered may seem at first rather radical I believe that further study will show that they offer a more logical explanation of the conditions than has hitherto been presented. I trust that some of the suggestions may prove of assistance in solving the many puzzling drainage problems of northeastern Ohio.

ORIGIN OF TASTE BUDS IN THE ORO-PHARYNGEAL CAVITY OF THE CARP.

(*Cyprinus Carpio* Linnaeus).

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According to the doctrine of germ-layer specificity all nervous structures, including taste buds, are derived from the ectodermal layer of the embryo. The mucous membrane lining the digestive tract, including the pharyngeal cavity, is said to originate from the endodermal layer, whereas, that of the oral cavity is generally conceived to arise from ectoderm the presence of which is due to invagination during the formation of the stomodaeum. Most authors agree that the exact limits of ectoderm and endoderm in the oro-pharyngeal cavity cease to be distinguishable after the rupture of the oral plate. In fishes taste buds appear throughout the entire extent of the epithelial lining of this cavity. They occur on the floor, roof, and sides, including the inner surfaces of the gill arches, extending oftentimes even into the oesophagus. In spite of the difficulties in determining the exact boundaries of the two germ layers in this region, the opinion prevails that these structures are derived from ectoderm. In order to account for the presence of these so-called ectodermal derivatives in the pharyngeal cavity, a region generally conceived to be endodermal in derivation, many investigators hold to the opinion that they are derived from ectoderm which has migrated into this region either by way of the oral or the pharyngeal clefts.

Beard ('88, p. 879) claimed that he had evidence to prove that the end organs of taste arise from epiblastic thickenings which have migrated through the gill clefts into the pharyngeal cavity. Fahrenholz ('15) maintained and was supported in his contentions by Jacobshagen ('11, '12) that the oro-pharyngeal cavity in Selachians up to the commencement of the oesophagus is lined with mucous membrane derived from ectoderm. He employed the fact that placoid scales and taste buds occur in this region as evidence to support this contention.

Cook and Neal ('21, p. 48), on the other hand, claimed that in elasmobranchs "the whole pharyngeal cavity is endodermal in its origin and that there is little or no inward migration of the ectoderm into the pharynx." In regard to the origin of taste buds in this region they hold that the endoderm, within which they first make their appearance, is the active layer.

Keibel ('12, p. 183), in discussing this problem, makes the statement that "The majority of the taste buds lie undoubtedly within the entoblastic territory." For this reason he thinks that the doctrine that these structures are ectodermal in origin "is not free from objection."

Many investigators have attempted to account for the origin of taste buds in this region on the basis of their nervous innervation. Although this phase of the problem is not within the scope of the present paper some of the main contentions bearing on this point will be outlined here, since they illustrate, at least, the complexity of the problem as well as the diversity of opinion among investigators.

It has been conclusively established that taste buds in the oro-pharyngeal cavity as well as those on the external surface of the body of fishes are innervated by nerve fibers which belong to the so-called fasciculus communis system. These communis fibers have been traced from their nuclei of origin or termination in the brain, through the roots and ganglia of the cranial nerves, to their peripheral termination. It has been determined that the central termination of these communis fibers is in the vagal and facial lobes of the medulla oblongata. In the family cyprinidæ these lobes are greatly hypertrophied, the latter having fused to form the so-called tuberculum impar. The remarkable enlargement of these lobes is said to be correlated with the abundance of taste buds in the oro-pharyngeal cavity of these fishes.

We are greatly indebted to Professor C. Judson Herrick for much of our present knowledge concerning the peripheral gustatory pathways in fishes. According to this author, whose numerous papers on this subject are well known, taste buds in the oro-pharyngeal cavity are supplied by communis or gustatory fibers from the VII, IX, and X cranial nerves, while those on the outer surface of the body are supplied by the VII nerve. These results have been corroborated by other investigators for various species of fishes.

Allis ('95, '97) claimed that the fasciculus communis system in *Amia* is distributed exclusively to taste buds. Other investigators found that there are two kinds of fibers in this system each of which has a distinct distribution—one to taste or terminal buds and the other to the mucous membrane. The latter are unspecialized visceral sensory fibers ending freely in the mucosa of the digestive tract including the mouth and pharynx.

Johnston ('98, '05, '10) advanced the hypothesis that the communis system is exclusively visceral and hence endodermal, as compared with the general cutaneous and acusticolateral systems which are related to strictly ectodermal sense organs. Herrick ('98, p. 170) criticised this hypothesis on the grounds that it "seems to lead us into serious difficulties, for, in the first place, the terminal buds of the outer skin, which are very numerous in some fishes and which can hardly be other than ectodermal, are apparently all innervated from the communis system. Again, the taste buds of the mouth of fishes all or nearly all lie in the region of the stomodaeum and are therefore probably of ectodermal origin." Strong ('98 p. 173) likewise offered this criticism, at the same time suggesting that the association of gustatory fibers with visceral fibers "might be accounted for on the supposition that the end bud organs originate on or near entodermal surfaces."

Cole ('98, p. 142) at first considered the fasciculus communis fibers to belong to the visceral system, although he pointed out that it is difficult in the region of the visceral clefts to determine where the somatic region ends and the visceral region begins. In a later paper ('00, p. 320) he seems to think the opposite condition has occurred, that is, "that it was originally a cutaneous system, which has, like the early teeth, invaded the mouth."

In regard to the relationship of the terminal buds in the skin and the taste buds in the oral cavity, Herrick ('99, p. 20) pointed out that "it is generally assumed that these two classes of buds have a common origin, as well as a common structure and innervation." In a later paper ('00, p. 308) he suggested that the terminal buds are probably ectodermal in origin and that "if they arose first as gustatory organs, their migration inwards in the stomodaeum toward the tongue and teeth is intelligible. Whether the others retained this function or became tactile organs, their migration to the exposed surfaces of the body (barblets, fins, etc.) is equally intelligible."

Johnston ('05, '10) entertained an opposite view, namely that the taste organs originated in endodermal territory and secondarily spread to the outer surface of the body. He not only maintained that the evidence is all in favor of the origin of taste buds from endoderm, from the standpoint of nerve distribution, but, also claimed ('10, p. 41) that in teleosts (*Corregonus* and *Catastomus*) taste buds first appear in the pharynx and oesophagus where there seems to be no possibility of origin from any other source than endoderm."

Landacre ('07) in his studies on the time and place of appearance and the direction of spreading of taste buds in *Ameiurus melas* found (1) that they "appear simultaneously in the extreme anterior portion of the oral cavity (ectoderm) and on the endoderm of the first three gill arches," (2) that those of the pharynx spread posteriorly into the oesophagus and that those of the oral cavity spread posteriorly until they reach the pharyngeal group, (3) that no buds spread from the pharyngeal group to the outer surface of the body while the cutaneous buds, which appear later than the oral group, are continuous with the latter just inside the lips. It is evident from these results that this author confirms the occurrence of taste buds in endodermal as well as in ectodermal territory, but disagrees with Johnston's suggestion that buds spread from endodermal into ectodermal territories.

In regard to the possibility that buds in ectodermal territory may actually spread into endodermal territory, this author ('07, p. 47) suggests that this "is probably peculiar to *Ameiurus* and has no bearing whatever on the question as to where taste buds first appeared phylogenetically." However, he expressed the opinion ('07, p. 47) that "the evidence seems to be in favor of Johnston's hypothesis ('05, '06) that buds in primitive forms appear first in endodermic territory, since taste buds are always supplied by communis fibers which are visceral in their relationship as far as their central nuclei are concerned."

Another significant problem in connection with the nervous innervation of taste buds and its possible bearing on their germ layer origin is that in regard to the question as to whether the buds appear fortuitously and independent of their gustatory nerves or whether the nerve fibers take the initiative and stimulate the production of buds in the epithelium. The significance of this problem is apparent as illustrated in the case

of cutaneous and oro-pharyngeal buds which are innervated by communis fibers terminating centrally in a morphological single center and distributed peripherally by the VII nerve.

Olmstead ('20 b) and May ('25) proved by experimental methods that in *Ameiurus* degeneration of the gustatory nerve after sectioning is followed by degeneration of the taste buds and regeneration of the nerve is accompanied by the reappearance of taste buds. These authors hold, therefore, that the presence of the gustatory nerve is the causative factor in the differentiation and transformation of the epithelial cells into taste buds. Professor Landacre ('07) whose investigations on the appearance of taste buds in *Ameiurus* were embryological rather than experimental, made the significant statement in regard to the appearance of taste buds supplied by the VII nerve, that "some of these fibers on reaching the surface produce taste buds, whether in the ectoderm or endoderm."

It is obvious, therefore, that the solution of the problem as to the origin of the taste-buds in the oro-pharyngeal cavity hinges on the derivation of the mucous membrane lining this cavity. In a former paper ('29) the author published the results of a study of an embryological series of carp, ranging in age from the time the eggs were fertilized until fifteen days after hatching—the object being to determine the germ-layer origin of the oro-pharyngeal mucous membrane and its relation to the development of the pharyngeal teeth. In order to determine what germ layers contribute to the formation of the mucous membrane lining this region it was necessary to trace the development of the foregut from the earliest stages of germ-layer differentiation, and, to study the mode of formation of the mouth and gill-slits with the view to determining whether or not ectoderm migrates into the oro-pharyngeal cavity during their formation.

The results of that study presented evidence that the mucous membrane lining the oro-pharyngeal cavity consists of two types of cells each derived from a distinct source, a superficial layer of flattened cells the presence of which is accounted for by the inward migration of the epidermal stratum during development of the mouth and gill-slits, and, a deeper layer of columnar cells. The latter represents the original endodermal layer which was laid down during the formation of the primordial foregut. Furthermore, proof was offered that the enamel

organs of the pharyngeal teeth are formed from the deeper epithelial layer of the pharyngeal mucous membrane and hence are endodermal in origin. Since this was the conclusion arrived at in the case of these structures, which are considered to be ectodermal in origin, the author desired to extend his investigations to other so-called ectodermal derivatives, namely taste buds.

The taste buds in the oro-pharyngeal cavity of the carp (Fig. 1) are essentially similar in structure with those described for other teleosts. They are somewhat pyramidal in shape with the apex projecting a considerable distance beyond the level of the mucous membrane. They consist of a compact group of enormously elongated epithelial cells with greatly attenuated distal extremities and with enlarged basal ends in the region of the nuclei. As this embryological series had been stained with Delafield's haematoxylin and counter stained with eosin, no special staining technique was employed in the study of these buds. Consequently it was impossible to study the structure of the buds in great detail or to determine whether or not so-called sustentacular or basal cells were present. Neither was it possible to determine the relationship of the gustatory nerve endings with the proximal extremities of the taste cells. However, it has been conclusively established by other investigators that the sense cells of the taste bud are in contiguity and not continuous with the gustatory fibers which supply them.

The first appearance of taste buds was observed in a larva 22 hours after hatching (Fig. 2). They were immature, of course, but could easily be distinguished by means of the accumulation of cells into papilla-like structures. They bear a superficial resemblance to the neuromasts, but unlike the latter they arise as evaginations from the basal layer. Furthermore they could not be confused with neuromasts as these do not appear in this region. As can be seen in Figure 2, these immature buds are composed of columnar cells which are continuous with the lowermost epithelial layer of the mucous membrane. The cells are not as yet differentiated into sense cells but are apparently similar to the columnar cells of the basal layer of the mucous membrance with which they are continuous. The superficial flattened epithelial layer of the mucous membrane can be seen to pass uninterruptedly over these groups of proliferating columnar cells.

These primordial taste buds make their appearance simultaneously in the oral and pharyngeal cavities. This agrees with the observations made by Landacre on *Ameiurus* ('07) and is contrary to those made by Johnston ('05 and '10) on *Corregonus* and *Catostomus*. A careful examination of preceding stages failed to reveal the presence of any structures that would likely be immature taste buds.

In Figure 3 is shown a developing taste bud on the roof of the oral cavity of a larva 23 hours after hatching. This bud, with a section of a nerve shown at its base, has evaginated considerably, giving it a more or less oval shape with its cells somewhat radially arranged. By 26 hours after hatching the taste buds in the pharyngeal cavity are not only more numerous but appear to be more highly developed than those in the oral cavity. This observation is in agreement with that of Johnston ('05, '10) for *Corregonus* and *Catostomus* but disagrees with that of Landacre for *Ameiurus* ('07). Figure 4 shows one of these buds on the inner surface of a gill arch. This bud is more highly developed than in figures 2 and 3 with a somewhat oval shape. This increase in the size of the buds seems to be due to the elongation of the cells rather than by their multiplication. The cells in the center of the bud are more elongate becoming gradually shorter until at the margins they pass over continuously into the columnar cells of the mucous membrane. The distal extremities of these cells have not penetrated through the flattened epithelial covering of the bud. Neither have they assumed the attenuated shape of the typical taste cell. However the relationship of these cells to the columnar epithelium of the mucous membrane is still evident. The relation of the superficial flattened epithelial layer of the mucous membrane to the developing buds is quite apparent in these figures. It is evident that it follows their contour but apparently contributes nothing to their formation.

The next stage in the development of the taste buds is represented in Figure 5, which shows their appearance in a larva 28 hours after hatching. The entire bud is still somewhat oval in shape. However, the central cells of the bud, those which are destined to become taste cells, are considerably more elongated than those in the preceding stages. They have begun to become somewhat attenuated at their distal extremities and seem to possess an enlargement near their basal ends, due apparently to the presence of their nuclei. This central core of

elongated sense cells thus assumes a more or less pyriform-shape, whereas the entire bud with its cluster of taste cells and its covering of flattened epithelial cells possesses a somewhat oval-shape. This oval shape is apparently due to the latter layer of cells, which passes over the group of taste cells and covers it in a cap-like manner. The distal or free ends of the taste cells do not appear to penetrate the surface of the mucous membrane, but are apparently covered by the superficial flattened epithelial layer.

Figure 6 shows a taste bud at a later stage of development. This bud is found on the roof of the pharyngeal cavity of a larva 40 hours after hatching. The free extremities of the elongated taste cells have broken through the superficial flattened epithelial covering and end freely above the surface. The superficial epithelial layer, having been broken, now surrounds the attenuated ends of the taste cells thus furnishing the latter with a pore as well as a covering.

The final stage of development is shown in Figure 1, which is a mature taste bud in a larva 42 hours after hatching. The structure of this bud has already been described.

It remains then to interpret its structure in the light of its germ-layer origin. It is evident from the foregoing description of the development of the taste buds in the oro-pharyngeal cavity of the carp that the elongated taste cells are modified or differentiated columnar epithelial cells which are continuous with the lowermost layer of columnar epithelium of the mucous membrane of this region.

It has been conclusively established by other investigators that all taste buds wherever found are derived from the germinating or Malphigian layer of the epidermis. Cook and Neal ('21, p. 48) claimed that in *Squalus acanthias* "it is within the endoderm that the taste cells first make their appearance in a 45 mm. embryo by the local thickening of the epidermis and the differentiation of cells of the stratum germinativum." Keibel ('12, p. 184) in his description of the development of taste buds, claimed that "the basal cells of the epithelium lose their usual low cylindrical form and increase in size noticeably."

May ('25, p. 387) stated that when the taste buds degenerate following degeneration of the gustatory nerve "the dermal papillæ are then no longer capped by taste buds, but end among cells which do not differ in appearance from the surrounding epidermal cells." This author claimed that in the process of

formation of taste buds, following regeneration of the gustatory nerve, "it is the ordinary epithelial cells which become transformed into the gustatory cells."

A rather interesting side-light on this problem has been suggested by Botezat and Parker (quoting from Cook and Neal, '21, p. 47) namely, "that these modified epithelial cells to which the name taste buds is given may be primarily secretory, and that the nerves receive their stimulation through the response (secretion) of these cells to the stimulating substances." The latter authors go on to say that "such an explanation would rule out the term 'sense-cell' as applied to the groups of slender cells making up the taste-buds." They add further (p. 52), that if these so-called sense-cells are glandular, the deduction that all nervous receptor cells, including taste cells, are of ectodermal origin is a logical non-sequitur. However, as was suggested by May ('25, p. 404), when the Golgi method is applied to the taste buds and their gustatory nerves the former react in differential staining in the same way as the nerves themselves. It would seem therefore that these modified epithelial cells, which make up the taste buds, assume the characteristics of typical nervous receptors. In spite of this, however, the doctrine that all nervous receptors are ectodermal in origin is not in accordance with the results set forth in the present paper.

It is evident from these results that the superficial flattened epithelial layer of the mucous membrane lining this region contributes nothing to the taste bud other than a covering for the distal or free extremities of the taste cells and that, since it surrounds these extremities, it thus forms a pore. Since the author demonstrated in a previous paper ('29) that the lowermost or columnar layer of the mucous membrane, from which the taste cells are derived, represent the original endodermal layer of the foregut, therefore the conclusion arrived at here is that the taste cells, which form the taste buds, are endodermal in origin.

Summary.

1. The first appearance of taste buds in the oro-pharyngeal cavity of the carp was observed in a larva 22 hours after hatching.

2. These immature buds make their appearance simultaneously in the oral and pharyngeal cavities.

3. By 26 hours after hatching the pharyngeal buds were more numerous and highly developed than the oral buds.

4. Typical mature buds were first observed in the pharynx of a larva 42 hours after hatching.

5. These buds are essentially similar in structure with those described by other investigators for other teleosts. They are composed of elongated taste cells with attenuated extremities which project beyond the superficial flattened epithelium.

6. The superficial flattened epithelium of the oro-pharyngeal mucous membrane contributes nothing to the taste buds other than their covering and furnishes them pores whereby the attenuated extremities of the taste cells reach the surface.

7. Undifferentiated taste cells first make their appearance (22 hrs.) as low cylindrical cells similar to those of the basal epithelium with which they are continuous.

8. These cells gradually elongate and assume the shape and characteristics of typical taste cells.

9. Taste cells are therefore derived from the basal epithelium by modification or differentiation.

10. Since the author demonstrated in a former paper that the basal epithelium of the mucous membrane lining the oro-pharyngeal cavity is endodermal in origin the conclusion arrived at in the present paper is that the taste buds in this region of the carp are derived from endoderm.

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EXPLANATION OF PLATE.

These Figures are enlargements of microphotographs.
Magnification × 1800.

FIG. 1. A mature taste bud on the inner surface of a gill arch in a larva 42 hours after hatching.

FIG. 2. The first primordial taste bud to be observed in the series. Found on the roof of the pharyngeal cavity in a larva 22 hours after hatching.

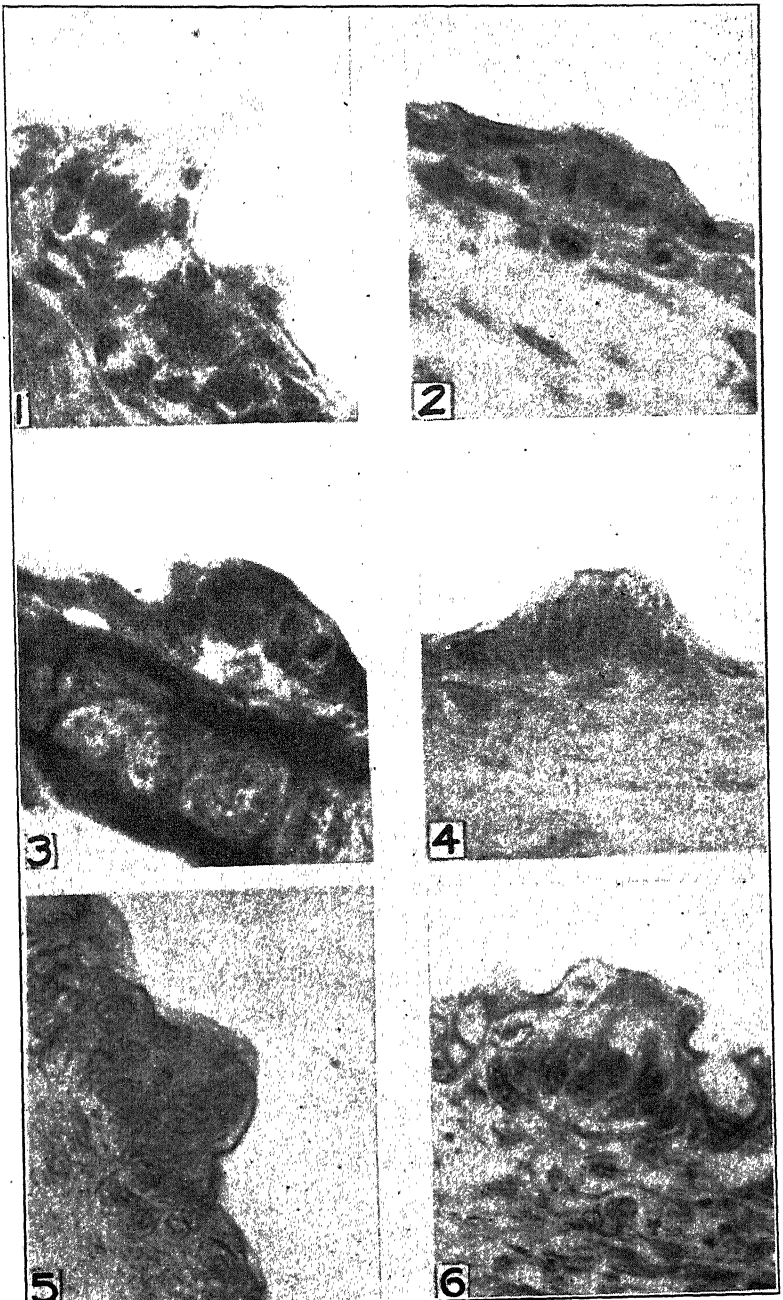
FIG. 3. A developing taste bud found on the roof of the oral cavity in a larva 23 hours after hatching.

FIG. 4. An immature taste bud on the inner surface of a gill arch in a larva 26 hours after hatching.

FIG. 5. A taste bud found on the roof of the pharyngeal cavity in a larva 28 hours after hatching.

FIG. 6. An almost mature taste bud on the roof of the pharyngeal cavity in a larva 40 hours after hatching.

NOTE.—In all these figures the superficial flattened epithelial layer of the mucous membrane lining the oro-pharyngeal cavity is comparatively easily distinguishable from the basal columnar layer. Nuclei of the cells in the former layer are shown in most of the figures, especially where this layer covers and follows the contour of the taste buds. The relation of these cells to the taste buds is quite evident in Figure 6.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VENATIONAL CHARACTERS IN TYPHLOCYBINÆ WINGS.

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The occasion for discussing this problem of wing venation of a group of small Homoptera has been brought forward by the criticism of W. L. McAtee which appeared in the Journal of the New York Entomological Society, Vol. 34, p. 158.

In commenting upon the wing drawings of Dikraneura which accompanied a discussion and revision of the genus by E. D. Ball and the writer, he makes the following statement: "The figures illustrating venation in the paper referred to are carelessly drawn in a number of instances. In general the sectors are drawn as if visible to the base of tegmen, while a leading characteristic of the subfamily Eupteryginæ is that the sectors are usually not visible basally."

Early workers referred to this basal condition of the wings as a possible character and later workers have frequently followed them without detailed work or sufficient and proper technique in study. The present criticism we trust resulted from unsuccessful attempts to examine the wings at their bases, following which it was merely assumed that this was a leading characteristic of the subfamily. Furthermore it is quite apparent by examining drawings and noting statements made, that Mr. McAtee has overlooked the veins in the basal portion of the Typhlocybid wing.

The statement that the sectors usually " are not visible basally" will not hold for the genus Dikraneura nor for the subfamily Typhlocybinæ as a whole, when thorough and careful study is made. In the genus Dikraneura the sectors are visible to the base of the tegmen in most specimens of every species examined, some more plainly than others. But even the faintest may be observed rather easily by the use of a microscope condenser. Photographs are exact reproductions of these characters, and the accompanying photographs of mounted slides of Dikraneura elytra from which drawings were made are typical examples which show the basal veins distinctly.

Many of these mounted slides were placed on demonstration at the Entomological meetings held in connection with the meetings of the A. A. A. S. at Philadelphia in December 1926.

Technique and Methods of Study.

Probably the chief reason that the veins in the basal portion of the elytra are not always seen is due to the fact that they are usually mounted on a slide in balsam for examination and when thus treated the basal one-half or two-thirds of the wing will be cleared by this solution to such a degree that the veins are not plainly visible. Especially is this true since the veins in the basal portion of the elytra are usually narrower and less conspicuous than in the apical portion. On the other hand these structures are frequently examined without removing them from the insect. In this case the veins are not visible because they are not sufficiently prominent to use reflected light and the body is too thick to use transmitted light. For these reasons if the veins are to be seen as they really exist, it is necessary to mount the elytra in a film of air and seal the coverglass without using a clearing solution of any kind. They can be kept in this condition indefinitely for further examination. These slides are then placed under the microscope which is held in a horizontal position and by the use of a 90° prism on the ocular end of the microscope, and a projection lantern transmitting the light through the objective end, the wing greatly magnified, sharply focused and with the veins showing conspicuously, is thrown on a screen and traced. In order to be as sure as possible, of these structures, the slide is then studied under the microscope and every vein is verified. The lighting factor is very important where veins are rather faintly visible since a varied degree of transmitted and reflected light will greatly change the degree of visibility. Occasionally the light when placed at an angle so as to give the effect of a dark field illumination will aid greatly in making the veins conspicuous. The drawings are then inked. All the illustrations cited as carelessly drawn were made in the manner described above after thorough study and care, with the exception of three which were made from unique types where the wings could not be removed. One of these is in the private collection of W. L. McAtee at Washington. The writer is not certain of the correctness of these three illustrations. In all other

cases the drawings were made as cited above and although errors may have occurred, care was exercised in an attempt to portray the venation correctly.

DISCUSSION.

In further commenting upon the drawings of Dikraneura wings he states "no fewer than six different styles of fusion of

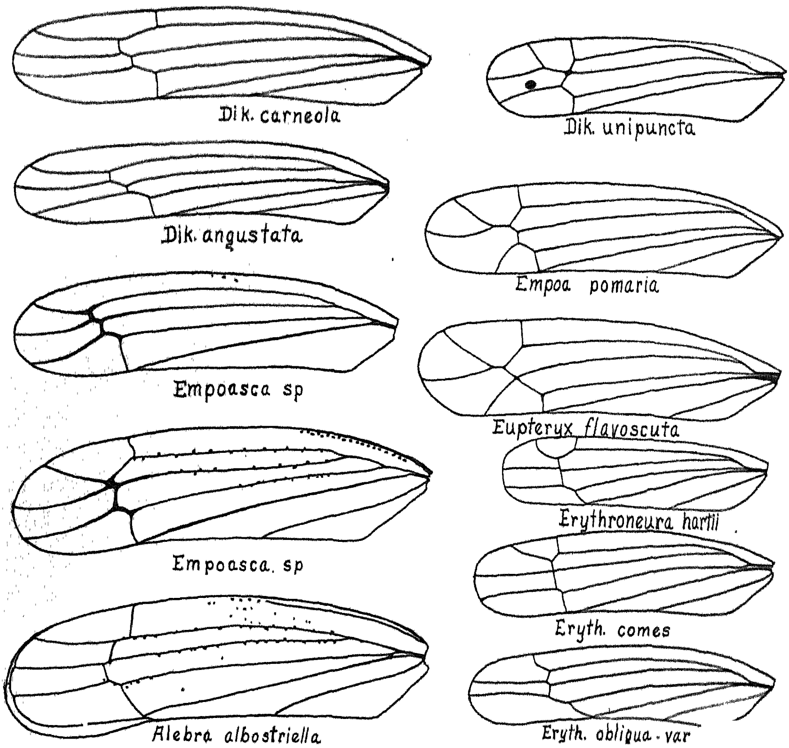

FIG. 1. Venation in Typhlocybinæ.

these veins basally are shown; a state of affairs which if actually exhibited by the specimens would compel their distribution to widely separated taxonomic groups." These groups are not named and we are left in doubt as to their identity.

This criticism is especially interesting since on the same page of his paper and in referring to a variable character in the apical portion of the wing, used for a generic separation, he states that it is "too variable to serve as the basis for such a

trenchant character." When these variations are pointed out by another worker however no consideration is given to them, the variation would be absurd and the specimens would be placed in widely separated taxonomic groups.

The point in question here is very similar to that at the apex of the wing, a question of the distance of the point of fusion of veins from the base of the wing, and which veins unite farthest from the base. This is apparently quite variable or seems to be as one studies it in a series of specimens. When species and genera are considered the variation is even greater.

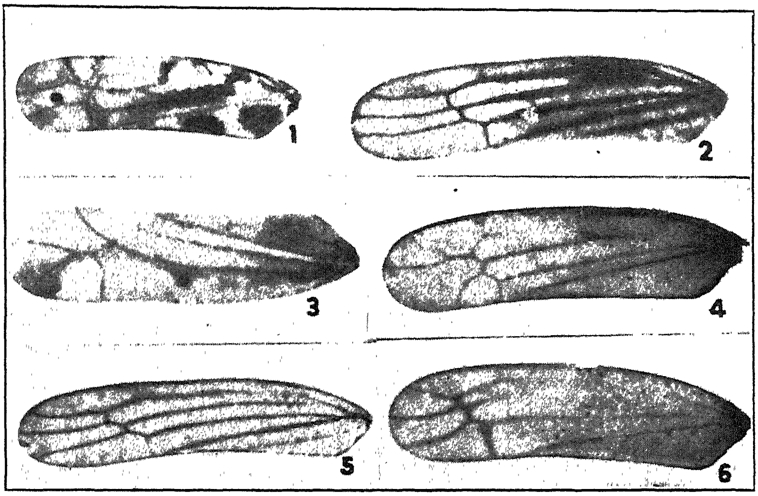

FIG. 2. Venation as shown by photographs.

Regardless of what the original condition may have been, we must study the present fusion of veins as we find it and must not assume that certain types of fusion would widely separate certain species unless we can prove it.

The great majority of Typhlocybid wings display the type of venation at the base as seen in *D. carneola* and *D. angustata* where "R" and "M" unite at the base before their fusion with "Cu" or the apparently united veins "Cu" and "1st A". This apparently is the rule, but there are exceptions. In some cases "Cu" will bend very sharply toward "1st A" and either unite with it or run parallel and proximal to it. Occasionally it bends sharply back and unites with "R" and "M" which are fused beyond this point. In some cases "R," "M," "Cu"

and "1st A" all seem to unite or fuse at about the same distance from the base, or if not fused, run parallel and so close to each other that the microscope does not designate them as separate veins. Perhaps the most interesting or peculiar condition is a fusion spur that occasionally unites "1st A" and the main trunk of "R" and "M" just beyond or at the point of fusion with "Cu." This is confusing in many instances if one attempts to trace the fusion point of "Cu."

In the case of *D. unipuncta* "R" does not fuse with "Sc" but runs very close to it and fuses in the usual manner with "M." In the drawing previously published by the writer the fusion portion at the base was omitted and the drawing was misleading. The second anal vein is frequently absent in the wing.

In certain species of *Alebra*, *Empoasca*, *Empoa* and *Erythroneura* "R" and "M" are frequently shown only faintly on the disc of the elytron and these faint veins are closely bordered by a row of pits or tubercles. The fusion of these veins basally is usually plainly visible or conspicuous. By properly focusing and adjusting mounted wings these veins can be traced in pratically every case from the apical portion of the wing where they are most prominent to their points of fusion at the base.

In view of these facts it would seem that the criticism was unjust and furthermore it would seem absurd to state that a drawing was "carelessly made" if one had never seen the structure which another was attempting to illustrate and knew nothing of the care exercised and the methods and technique employed in an attempt to describe and portray the structures present.

TEMPERATURE GRADIENT IN THE EGG-LAYING ACTIVITIES OF THE QUEEN BEE.

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INTRODUCTION.

It is generally thought that the hive temperature at which the queen is stimulated to start her egg-laying activities in early spring is about 93 degrees F. One might gather from this that when brood-rearing has once been stimulated the above temperature is maintained in the brood nest, and that the queen is rather fixed in responding by egg-laying at any other than the temperature stated. It was because of some doubt concerning this idea that this study of the gradient in egg-laying was undertaken.

The writer wishes to express his appreciation to Professor Herbert Osborn for his helpful suggestions on this work.

APPARATUS.

The thermocouple method of taking temperatures lends itself admirably to this type of work. The use of these instruments avoids any abnormal reactions which might result in stimulating the colony and thus causing a higher temperature which was often the case in the old method of taking temperatures with mercuric thermometers. Also the readings are accurate and almost instantaneous.

A two pound package of bees with an untested queen was placed in a four frame vertical observation nucleus. Before any study was undertaken, the bees were left long enough so that they had become fully adjusted to their environment and had begun broodrearing. The four frame vertical observation nucleus consisted of four Hoffman frames placed one above the other. The sides of the observation nucleus were of glass. On Each side of each frame were three thermocouple junctions inserted through the glass, making six junctions for each frame and twenty-four for the entire nucleus. (See Fig. 1, for arrangements of the thermocouple junctions). This observation nucleus was placed in a dark room where the temperature was

quite constant. Red lights, to which bees made no abnormal response, afforded illumination for the worker to carry on his observations. An extension of the entrance of the observation nucleus was made which led to the outside of the building and thus allowed flight activities for the bees.

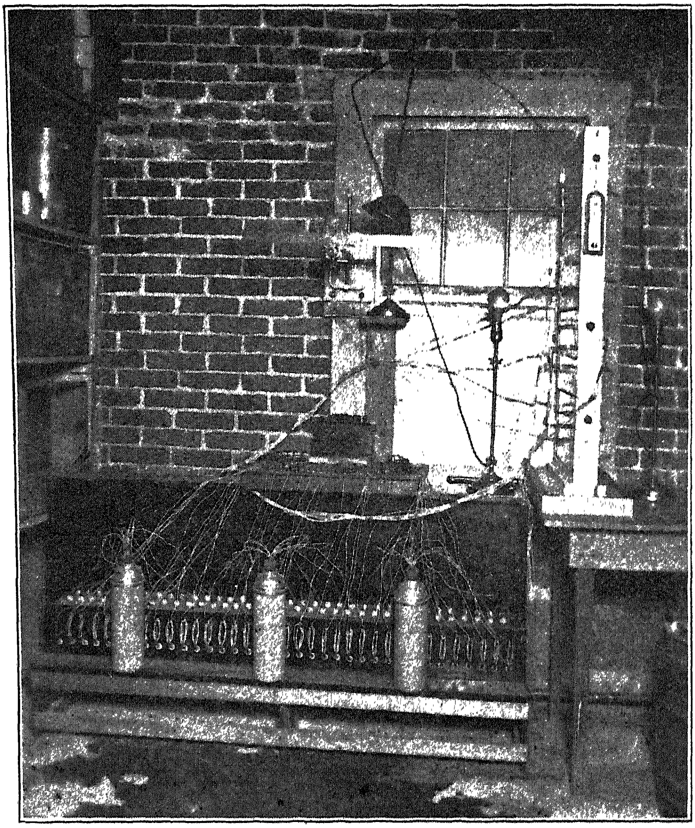

FIG. 1. GENERAL ARRANGEMENT OF APPARATUS WHEN STUDYING THE EGG LAYING ACTIVITIES OF THE QUEEN BEE.

GENERAL PROCEDURE.

Observations on this experment which were carried on in 1928 were begun on the morning of June 5th and continued through the evening of June 9th. These observations were arranged in three thirty-minute periods daily; one in the morning, one at noon, and one in the evening, so as to obtain a fairly accurate representation of what took place during each day.

In the study of the gradient in the egg-laying activity of the queen bee, observations were taken on the amount and position of the brood and the bees; the number of eggs laid by the queen; the exact position of these eggs, and the temperature of the region in which the eggs were laid. After these data had been gathered for the entire period, they were arranged in a temperature gradient table which started at 73 degrees F. and with intervals of 3 degrees (ie. 73-76-79 etc.) culminated at 94 degrees F. At these various temperatures, the number of eggs laid during the observation periods were tabulated (Table I). Fig. 2 gives a graphic representation of the tabulated data.

TABLE I.

Influence of Brood Nest Temperatures on the Egg Laying Activity of the Queen Bee.

Temperatures Degrees F.	71½° 73°	74½° 76°	etc. 79°	82°	85°	88°	91°	94°
Number of eggs laid by the queen..............	0	2	19	34	67	110	96	22

Discussion.

As shown in the table, the egg-laying activity of the queen was carried on from 73 degrees F. to 94 degrees F. thus showing conclusively that after the queen has once started her egg-laying activities in the spring she is not absolutely confined in her egg-laying processes to a rather narrow range of temperatures. However, the temperature range is relatively very narrow at which she responds most actively to egg-laying, as shown in Table I. This region ranges from 88 degrees F. to 91 degrees F. It is interesting to note the gradual gradient from the optimum egg-laying temperature to the lowest egg-laying temperature. Of equal significance is the egg-laying gradient from the optimum temperature to the highest temperature recorded or 94 degrees F. A comparison of the gradient in egg-laying taking place from the optimum to the lowest temperature with that from the optimum to the highest temperature indicates that the fall of the gradient in egg-laying is

much greater in the latter than in the former. This is further substantiated in some observations already reported.*

During the observation period, other factors were recorded which must be given careful attention in order to make a clear diagnosis of the gradient in the egg-laying of the queen bee.

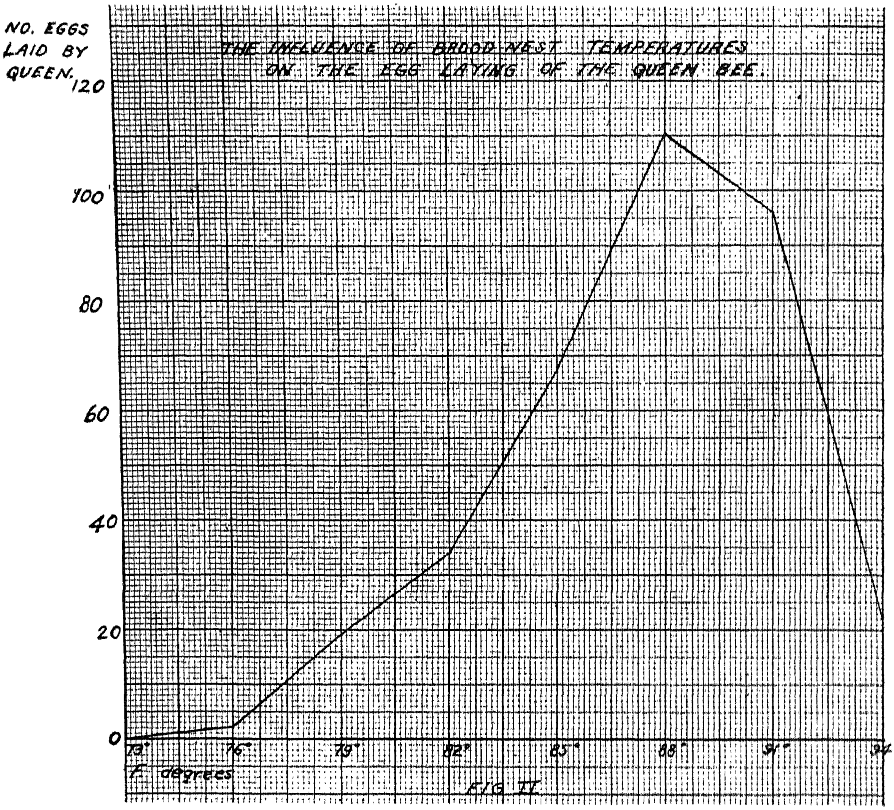

FIGURE 2.

The fact must not be overlooked that this experiment was conducted during the spring when brood-rearing is more intensive than at any other time of the year. When conditions are normal, as was the case in the colony used in this experiment, there is a rapid expansion of the brood-nest. Because of the ability of the queen for heavy egg-laying during

*Dunham, W. E. The Relation of Heat to Brood Rearing. Gleanings in Bee Culture. 57: 359–362. June, 1929.

the spring period, she not only keeps the area from which brood is emerging filled with eggs, but she also lays eggs on the outer region of the brood-nest, thus constantly increasing the area occupied with brood. It is quite evident that the warmest temperatures will occur in the central region of the brood-nest and that the cooler temperatures at which the queen will lay, will occur at the junction of that portion of the comb unoccupied with brood with that containing brood.* Thus it is obvious that when intensive brood-rearing is going on which results in a rapid expansion of the brood-nest, the gradient in egg-laying from the optimum temperature to the low extreme will cover a wide range.

Having made a detailed study of the egg-laying gradient for this particular period of the year, certain correlations are suggested. Nolan's work brings† out very conclusively that there are definite phases in the brood-rearing curve during different parts of a year. In brief, he found that there are three distinct phases of the curve, which are: the initial brood-rearing phase, the major brood-rearing phase, and the contraction brood-rearing phase. Following the latter is a broodless period.

The initial brood-rearing phase begins early in the spring and follows the broodless period which might be termed a semi-dormant phase. In comparing the amount of brood present at this time with the number of bees to care for it and maintain the other activities of the hive, it is obvious that the ratio of the number of bees to the amount of brood is very high. As a result, the temperature where the queen begins laying would be quite constant. This would mean, then, that the temperature gradient in egg-laying would be confined to a small area with a slight temperature range. However, as the brood-nest becomes more and more expanded during this initial brood-rearing period, the range in the temperature gradient in egg-laying would become increasingly greater. The reason for this is that, as the brood-nest is rapidly expanding, the ratio of the number of individual bees to care for the increasing brood area and carry on the other activities of the hive becomes less and less. When this ratio has reached its

*Dunham, W. E. The Influence of External Temperature on Hive Temperatures during the Summer. Journ. Econ. Ent., 22: 798–800. 1929.

†Nolan, J. W. The Brood Rearing Cycle of the Honey Bee. U. S. Dept. Agric. Bul. No. 1349.

extreme, the temperature gradient in egg-laying from the optimum temperature to the low temperature will reach its widest range. As the brood emerges, and the ratio of the number of individual bees to care for the brood and the duties of the hive increases, the range in the temperature gradient of egg-laying becomes increasingly less. Also correlated with the increasing number of bees in a hive is an increase of the temperature in the central upper portion of the brood area to more than the optimum temperature regardless of the activities of the bees which tend to hold the temperature rather constant. The fact must not be overlooked that some heat is given off by the brood due to its metabolic activity.

Another interesting correlation occurring during the initial brood-rearing period is the difference between weak and strong colonies in the temperature gradient in egg-laying. In weak colonies this gradient from the optimum temperature to the lowest temperature covers a wider range of degrees and is also extended over a longer period of time than is the case in strong colonies. Because of the small number of bees in weak colonies, the queen soon has the area of the hive filled with brood where the bees are able to maintain a favorable temperature. In such a case, because of the tendency for a rapid expansion of the brood-nest, the queen responds by laying in cooler temperatures than she would otherwise.

The recommendation of beekeeping experts to leave packing on colonies until weather conditions in the spring have become settled, also has a direct influence on the temperature gradient in the egg-laying of the queen bee. With this insulating layer around the hive, the bees are able to maintain the favorable egg-laying temperature over a larger area of the hive, than they could otherwise. This would result then in the temperature gradient in the egg-laying of the queen covering a narrower range from the optimum temperature to the lowest temperature than if the colonies were unprotected and consequently she would lay eggs at a much more rapid rate.

Another interesting phenomenon which takes place during the initial brood-rearing period is that, as one goes northward from the southern states, the intensity of brood-rearing becomes increasingly greater. It has been suggested that the intensity of brood-rearing increases as the length of the broodless period increases. The writer is not in accord with this belief but

attributes it to certain other conditions found in the northward regions.

The writer is of the opinion that if a queen were taken from a northern colony where the broodless period had been long and placed at the beginning of the initial brood-rearing period in a colony in the south, that the intensity of brood-rearing and magnitude of the initial brood-rearing curve would undoubtedly correspond very closely to that of other colonies in the south where the queens had been wintered over with the colony and the broodless period had been short. It has already been shown that if a queen from the south where the broodless period had been short were introduced at the beginning of the initial brood-rearing period to a colony in the north, the intensity in brood-rearing and the magnitude of the initial brood-rearing curve would correspond very closely to that of other colonies in the north where the queen had been wintered over with the colony. A good example of this is the practice among northern beekeepers of sometimes buying from the south, pound packages of bees with a tested queen. The bees are young and have never passed through a broodless period which eliminates any possible argument that over wintered bees factor in the magnitude of the initial brood-rearing curve in the north. However, the queen in order to be of a tested grade and shipped out this early in the season must have been reared the previous year and have passed through a southern winter where the broodless period is short. A package of bees with a tested queen which is shipped so that it begins brood-rearing about the same time as brood-rearing starts in northern colonies, begins brooding just as intensively and the final peak in the initial brood-rearing curve reaches the same magnitude as in northern colonies where the broodless period has been long. It is quite evident then that the length of the broodless period is not the determining factor in the magnitude of the initial brood-rearing curve but that there are other conditions that are present as one goes northward that are not present in the southern states which have a direct bearing on the magnitude of the initial brood-rearing phase. One of the important factors which has a direct bearing to some degree at least on the temperatures that occur within the hive must be external temperatures.

As one goes northward, the temperatures occurring in early spring when brood-rearing starts, increases gradually as the

season advances. Thus it requires a longer time before external temperatures occur which are as high or higher than the optimum egg-laying temperature. Because of these cooler conditions, even though the population of the colony increases, there is a longer time for the queen to lay on the lower scale of the optimum egg-laying temperature as well as at the optimum egg-laying temperature. Since the gradient is much slower on this side of the scale, it results in the fact that the initial brood-rearing curve will reach a high magnitude.

In the south one finds a reverse condition. The temperatures occurring in spring when brood-rearing starts, increase quite rapidly as time goes on and so in a short time external temperatures occur which are as high or higher than the optimum egg-laying temperature. Because of these higher temperatures along with the increased population of the hive, there is a large portion of the hive where the temperature is on the higher scale of the optimum egg-laying temperature. Since the gradient is much more rapid on this side of the scale, the initial brood rearing curve will not reach a high magnitude.

NOTES ON THE ODONATA OCCURRING IN THE VICINITY OF SILVER LAKE, LOGAN COUNTY, OHIO, FROM JUNE 25 TO SEPTEMBER 1, 1930.

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Ohio State University.

Most of the collecting during the summer was done on or around Silver Lake (also called Lake Mac-O-Chee), a lake of about 75 acres located three miles west of Bellefontaine, at an elevation of 1090 feet. The highest point in the state, 1550 feet, is located about five miles northeast of this lake. Collections were made at other points as follows: Black Lake, a smaller lake two miles southeast of Degraff (one trip, July 15); along Buckongahelas and Bluejacket Creeks northeast of Degraff (several trips); in numerous swampy woods and ponds within a radius of four or five miles of Silver Lake (several trips); along the North Fork of the Miami near Indian Lake and in the marshes at the northeast of Indian Lake (one trip, July 24); along Mad River just south of Zanesfield (one trip, July 18); at Cedar Swamp, about five miles south of Urbana in Champaign County (two trips, July 22 and August 13); and along Mad River just south of Urbana (one trip, August 13). In spite of the fact that several trips were taken along the creeks west of Silver Lake and along Mad River, no gomphines were observed or taken. Apparently the trips were made too late in the season for these species.

There follows an annotated list of the species taken or observed:

Family AESCHNIDÆ.

Subfamily AESCHNINÆ.

1. **Anax junius** Drury. Fairly common near ponds and lakes throughout the summer. Last observed in tandem July 4.
2. **Aeschna umbrosa** Walker. Common throughout the summer on small ponds and in woody swamps. A few specimens were taken around the lake (Silver Lake).

Family LIBELLULIDÆ.

Subfamily CORDULINÆ.

3. **Epicordulia princeps** Hagen. Fairly common up to about the middle of July. It flies over the open water of the lake near the shore.

Subfamily LIBELLULINÆ.

4. **Nannothemis bella** Uhler. All the specimens of this species were taken at Cedar Swamp, where it was quite abundant. These little libellulines occur in the marsh grass in the open part of the swamp, rarely if ever flying above the top of the grass. They hover in the midst of the grass a foot or two above the ground, and then very suddenly—sometimes so quickly that the eye can scarcely follow the movement—they dart away and hover over another spot a few feet distant.
5. **Perithemis tenera** Say. Abundant throughout the summer. This species was most abundant around patches of yellow pond lilies, and one female was observed ovipositing in the water contained in a little pool formed by a lily leaf. Another was observed ovipositing on a piece of submerged vegetation. Though most abundant over water and around the lily pads, where they apparently never fly more than a foot or two above the water, they were occasionally taken in the marsh grass near the edge of the lake.
6. **Celithemis eponina** Drury. Only one specimen of this species was seen during the summer; it was observed flying over an open field about a mile northeast of Indian Lake, July 24.
7. **Celithemis elisa** Hagen. This species was observed occasionally during the summer, flying over the open water two or three feet above the surface, and sometimes alighting on cattails or bushes at the water's edge. A few were observed in tandem, but none ovipositing.
8. **Libellula luctuosa** Burmeister. Quite common on lakes and ponds throughout the summer.
9. **Libellula pulchella** Drury. Quite common throughout the summer near lakes, ponds, and streams, and occasionally observed three or four miles from water.
10. **Plathemis lydia** Drury. Quite common throughout the summer, occurring in situations similar to those in which the preceding species was found.
11. **Sympetrum obtrusum** Hagen. Three males were taken during the summer, June 28, July 1, and July 24, in swamp grass and swampy woods near the lake.
12. **Sympetrum rubicundulum** Say. Abundant throughout the summer. Occurs almost everywhere except over the open water of the lake.

13. **Sympetrum semicinctum** Say. Fairly common throughout the summer in fields near the lake.

14. **Sympetrum vicinum** Hagen. The first specimens were taken July 28. From that time on they were quite common, occurring most abundantly at the outer edge of the swamp and in fields near the lake.

15. **Leucorrhinia intacta** Hagen. This species was fairly common up until July 4, when the last specimen was taken. Most of the specimens were taken in cattails at the edge of the lake.

16. **Pachydiplax longipennis** Burmeister. This species was quite abundant up until August 1. It was most abundant in the cattails at the edge of the lake, but specimens were occasionally taken in the woods and fields some distance from the lake.

17. **Mesothemis simplicicollis** Say. This species was quite abundant up until about August 1. Most of the specimens were taken in fields near the lake and at the outer edge of the weeds around the lake, but this species is also quite common in the cattails at the water's edge.

18. **Tramea lacerata** Hagen. This species was observed occasionally up until July 4. It flies several feet above the surface of the water or land.

Family AGRIONIDÆ.

19. **Agrion maculatum** Beauvais. Abundant throughout the summer along small streams or ditches which are edged by or filled with thick vegetation.

20. **Hetaerina americana** Fabricius. Quite common from July 8 on, along small streams containing ripples. It flies close to the water and alights on the vegetation overhanging the water. The flight is very quick and rather irregular. Two males will frequently fly across the ripples, flying in circles around each other.

Family COENAGRIONIDÆ.

Subfamily LESTINÆ.

21. **Lestes eurinus** Say. One male, July 3, taken in a swampy woods.

22. **Lestes congener** Hagen. Several specimens, July 3 and 8, chiefly in swampy woods. One specimen was taken at the edge of a fairly dry (oak-hickory) woods some distance from water.

23. **Lestes unguiculatus** Hagen. Fairly common from the middle of July on. The specimens were taken in grassy swamps.

24. **Lestes forcipatus** Rambur. Specimens were taken occasionally during the summer in marsh grass or in woods near the marsh.

25. **Lestes rectangularis** Say. Quite common up until August 1 in the marshes and woods around the lake. This was the most abundant species of Lestes observed during the summer.

26. **Lestes uncatus** Kirby. Several specimens taken from July 1 to 8 in swampy woods.

Subfamily Coenagrioninæ.

27. **Argia apicalis** Say. Numerous specimens of this species were taken at Indian Lake July 24. Some were taken in tandem flying at the water's edge close to the surface, or alighting on the vegetation bordering the water. Others were taken alighting on bare ground, fallen logs, and the like not far from the water. In the open, away from the water, their flight seems to be quicker, and they are rather difficult to capture.

28. **Argia bipunctulata** Hagen. This species was taken at Cedar Swamp. It was quite abundant in the marsh grass in the open part of the swamp on the first trip, July 22, and much less abundant August 13. The flight is rather weak; they are not at all difficult to capture. Their flying is confined to the marsh grass; they never seem to fly above it.

29. **Argia tibialis** Rambur. One pair in tandem taken July 24 at Indian Lake.

30. **Argia violacea** Hagen. Specimens were taken from July 8 to August 5. It was fairly common along Buckongahelas and Bluejacket Creeks, where it seemed to prefer the vegetation along the edge of the stream. One male was taken in the marsh grass at Black Lake, July 15.

31. **Amphiagrion saucium** Burmeister. Numerous specimens of this species were taken at Cedar Swamp, where it was quite common, especially in the grassy part of the swamp.

32. **Nehalennia irene** Hagen. Fairly common up until August 1 in the grassy part of the swamps surrounding the lake. One female was taken at the edge of a fairly dry (oak-hickory) woods about half a mile from the lake.

33. **Enallagma hageni** Walsh. Two males, June 26 and 28, taken in the cattails at the edge of the lake.

34. **Enallagma geminatum** Kellicott. Two males, July 24, at Indian Lake, and numerous specimens in the bulrushes at the water's edge at Silver Lake the last week in August.

35. **Enallagma signatum** Hagen. Quite common throughout the summer, occurring over the open water of the lake, and occasionally back in the marshes. It is most abundant flying a rod or so from the edge of the cattails or marsh grass, a few inches above the surface of the water. Oviposition, on submerged vegetation, occurs in tandem. The female alights on the vegetation and the male holds itself up at an angle of about 45 degrees while the female lays her eggs.

36. **Enallagma vesperum** Calvert. A few specimens were taken during July. This is quite similar to *signatum*, but seems to occur more frequently in the grassy part of the swamp. One male was taken on a shrubby hillside on the south side of the lake.

37. **Enallagma exsulans** Hagen. Quite common throughout the summer, occurring in the cattails and bulrushes at the edge of the water, and occasionally in the fields and woods near the lake.
38. **Enallagma antennatum** Say. This species was quite common along Buckongahelas and Bluejacket Creeks, where it was found flying over the vegetation at the water's edge.
39. **Enallagma carunculatum** Morse. Quite abundant throughout the summer. It occurs in the cattails and bulrushes at the edge of the lake, back farther in the marshes, and occasionally in the woods and fields near the lake. Oviposition occurs in submerged vegetation near the water's edge.
40. **Enallagma doubledayi** Selys. Two males, June 26, taken on a grassy and shrubby hillside near the lake.
41. **Enallagma aspersum** Hagen. One male, July 3, in a swampy woods.
42. **Enallagma traviatum** Selys. Fairly common up until about July 3, occurring in situations similar to those in which *exsulans* and *carunculatum* are found.
43. **Ischnura posita** Hagen. Found occasionally throughout the summer in the grassy parts of the swamps around the lake, and in the swampy vegetation along streams.
44. **Ischnura verticalis** Say. Very abundant throughout the summer, occurring everywhere any other species was found. This was the most abundant damselfly observed during the summer.
45. **Anomalagrion hastatum** Say. One male, August 9, taken in a swampy woods.

Of these 45 species, four are new records for the state: *Aeschna umbrosa* (No. 2), *Nannothemis bella* (No. 4), *Argia bipunctulata* (No. 28), and *Enallagma vesperum* (No. 36). I am sure that *A. umbrosa* and *E. vesperum* have been taken in the state before, though I can find no published records to that effect. The record of *N. bella*, however, is certainly new, and that of *A. bipunctulata* appears to be the first record of its capture west of the Appalachian Mountains.

BOOK REVIEWS.

A DICTIONARY OF GREEK AND LATIN COMBINING FORMS USED IN ZOOLOGICAL NAMES. By EDMUND C. JAEGER. Charles C. Thomas, Publisher, Springfield, Ill.

Students in Biology will welcome this assemblage of technical terms showing the derivation and combining forms which are applicable in many different branches of Biology.

This book of one hundred pages includes the root form for more than one thousand words of common technical use.

KINETIC SPACE AND ITS SPECULATIVE CONSEQUENCES. By DR. R. W. MANLEY. Published by the author at Cleveland, Ohio.

Includes a discussion of the problems of space and contains a tribute to the work of Johann Kepler.

REACTIONS AND SYMBOLS OF CARBON COMPOUNDS. By T. CLINTON TAYLOR. Published by the Century Co., New York.

This work is a detailed presentation of the reactions and symbols used in organic chemistry, the aim of the book being to simplify the study of symbols by emphasizing the reaction and explaining fully the steps taken to formulate the symbol.

BLATCHLEYANA: A LIST OF THE PUBLISHED WRITINGS OF W. S. BLATCHLEY, A. B., A. M., LL. D., Together with a Chronology of His Life; The Fixation of Types of New Genera and Species Described by Him.

Doctor Blatchley has here brought together a complete list of titles of his papers and record of the new genera and species described by him with statement of their present location. It also includes a number of quotations from his various published books.

THE GALL WASP GENUS CYNIPS, A STUDY IN THE ORIGIN OF SPECIES. By ALFRED C. KINSEY. Waterman Institute for Scientific Research, Publication No. 42; Contribution from the Department of Zoology, Indiana University, No. 220 (Entomological Series No. 7).

This volume of 577 pages, including over four hundred figures, is much more than a monograph of the genus as it treats in a very exhaustive manner of problems of distribution, affinities and especially the lines of evolution for the different species with special reference to the American fauna. It is the outcome of twelve years of travel, research, and taxonomic studies and may well serve as a model for other taxonomic studies.

H. O.

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